NEWSHOLME'S SCHOOL HYGIENE

JAMES KERR, M.D.

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THE LAWS OF HEALTH IN RELATION TO SCHOOL LIFE

REWRITTEN FOR ALL SCHOOL WORKERS

BY

JAMES KERR, M.A., M.D.

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INTRODUCTION

"School Hygiene: The Laws of Health in Relation to School Life" was first published in the year 1887, and since then, with only one revision in the year 1903, it has had a large and continuing annual sale, having reached its twelfth edition in 1907.

When first published, "School Hygiene" gave a fair picture of the needs of public elementary schools in relation to personal and general hygiene, and formed a useful guide to the means for improving educational efficiency, so far as this is determined by hygienic considerations. For some years, however, the rapid advance of the science of school hygiene and the extensions of its practice in new departures in school-life have rendered it highly desirable that "School Hygiene" should be rewritten, if its continued sale were to be authorized.

My own work during recent years has not been specially concerned with the educational problems of school hygiene, except in so far as they form part of the general problem of Public Health; and it was evidently desirable that a new book should be written, merely using "School Hygiene" as its framework, by an authority on the educational side of hygiene.

The publishers are to be congratulated on having secured for this task the services of Dr. James Kerr, whose knowledge of the science of school hygiene and whose original work in promoting its advance are unrivalled among English-speaking communities.

"School Hygiene" has been entirely rewritten by him; and it is now not only a complete textbook of the subject, but it also embodies a large amount of original research matter. Although the publishers have wished my name to be retained on the title-page, I can claim no share in what, in my opinion, is a most valuable contribution to the science and practice of school hygiene.

ARTHUR NEWSHOLME.

March 1916.

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PART I

THE CHILD

CHAPTER I

PHYSIOLOGY, PSYCHOLOGY AND ETHICS IN RELATION TO HYGIENE

THE future of a child is largely determined by its training and education. This is true not only for what is commonly but erroneously regarded as the main function of education, the instillation of knowledge and the training of the mind; but also for that ethical culture of the will which is set out by Rein, in his *Outlines of Pedagogy*, as the highest purpose of education. To understand the objects of education and to avoid possible dangers in connection with it, the teacher should be acquainted with the principles of physiology, psychology, and hygiene in their application to child life.

The object being to secure *mens sana in corpore sano*, we must first consider the cerebral functions. The following is a brief outline of the **Anatomy and Physiology of the Nervous System** on which mental hygiene must be based.

Anatomy.—The nervous system of man is divided into two parts, *central and peripheral.*

The **central nervous system**, consisting of the brain and spinal cord, is encased in the skull and vertebral column; to the naked eye it consists of two kinds of material, viz. grey matter and white matter. In the spinal cord the grey matter occupies a central position with the white matter surrounding it. In the brain the grey matter lies chiefly superficially, and constitutes the whole surface or *cortex* of the cerebral hemispheres, which form by far the greater portion of the human brain. In order to increase the surface of the cortical grey matter, the cerebral hemispheres are thrown into ridges and furrows, forming *convolutions* which have a fixed and definite arrangement.

The **peripheral nervous system** consists of *nerves* which present the appearance of white threads, and are distributed to the skin, muscles, glands, and organs, forming a vast network by which each part of the body is linked up through the central nervous system to every other part. These peripheral nerves arise from the central nervous system in pairs. From the brain twelve pairs arise, and each of these twelve presents special and distinctive characters, the second pair, for instance, being distributed solely to the eyes, and the eighth pair solely to the ears. The spinal nerves, on the other hand, are all similar to one another in function. They spring from the spinal cord at regular intervals along its whole length ; each spinal nerve arises by two roots—an anterior root and a posterior root ; these two roots join and form the main trunk of the nerve, which gives off branches. Each branch usually contains elements derived from both the anterior and the posterior root.

The foregoing is a general account of the nervous system as it appears to the naked eye. Microscopically all animal tissues are built up of cells. The cells of the nervous system are very specialized. Each **nerve cell** consists of a minute club-shaped particle of protoplasm, from one side of which short tufts or *dendrons* proceed, and from the other side one or more minute nerve fibres (*axon*), the whole being called a *neurone*. The fibrils of the axon probably pass through the cell body and originate in the dendrons. It has been discovered that the fibrils between the almost innumerable individual nerve cells of the cortex of the brain are not in permanent contact. There are between them minute gaps, possibly of not more than $\frac{1}{1000}$ of an inch (*synapses*), which cease to exist during the transmission of nerve currents. This throws important light on the processes of thought and on the mechanism of mental fatigue. As nerve currents pass through the brain by definite paths, there must be some mode of making and breaking contact between neighbouring nerve cells. The exact nature of this mechanism is unknown. It may be that the dendrons of the nerve cells lengthen to make contact under the stimulus.

The **grey matter** of the brain and spinal cord consists chiefly of aggregations of such cells and fibrils. Every nerve fibre is a prolongation of a nerve cell and is dependent upon the cell for its nourishment. The **white matter** consists solely of fibres, each surrounded by a *medullated sheath*, consisting of a fatty, insulating material which gives rise to the white appearance. The white matter, therefore, since it contains no nerve cells, simply serves to link up the various parts of the nervous system together.

The **peripheral nerves** consist of great numbers of nerve fibres, for the most part medullated, each nerve fibre being a prolongation of a cell of the central nervous system; the nerves branch and branch again until each nerve fibre terminates in an *end organ* in the muscle, skin, gland, or other structure to which it is distributed.

Physiology.—When a peripheral nerve is divided the organ to which it is distributed is deprived of its connection with the central nervous system. Occasionally a nerve is found which supplies skin alone. When such a nerve is severed sensation is lost in the part of the skin to which it is supplied, and such a nerve is called a purely *sensory nerve*. Occasionally a nerve supplies a muscle alone, and its division causes paralysis of the muscle; such a nerve is termed a purely *motor nerve*. Most of the peripheral nerves are *mixed*, i.e. contain both sensory and motor fibres. All the sensory fibres of a spinal nerve enter the spinal cord by the *posterior* or *sensory root*, all the motor fibres pass out from the cord by the *anterior* or *motor root.* Thus, if the anterior root of a spinal nerve is alone severed, paralysis occurs in all the muscles supplied by the nerve, while sensation in the tracts of skin to which the nerve is distributed remains unimpaired. The reverse effect is produced by division of the posterior root alone.

Nerve fibres cannot originate impulses. They only transmit them; they bear the same relation to nerve centres as telegraph wires to the batteries which generate the current. The difference between motor and sensory fibres is in the nature of the peripheral and central connections of the nerves rather than in the fibres themselves.

The central nervous system consists, as we have seen, of grey and white material. The white material consists of medullated fibres which merely act as conducting agents, joining together various portions of the grey matter. The grey matter contains millions of nerve cells, which are aggregated together into centres. If the spinal cord be completely severed in the middle of the back, sensation and voluntary motion are lost below this part of the body, because the conducting paths to and from the brain are destroyed. Nevertheless, if under such circumstances the foot is pricked, movements occur known as **reflex movements.** Such unconscious movements play a large and essential part in the economy of life. The spinal cord is the site *par excellence* of reflex centres.

The **cortex** of the brain consists of cells aggregated together to form the higher sensory and motor centres. The main sensory cortical centres correspond to the senses of touch, sight, hearing, smell, and taste. Each of these centres occupies a special and separate convolution or series of convolutions. Stimuli from the external world are received by the sensory end organs, and are there converted into nervous impulses. For example, contact of a foreign body with the skin is converted by the endings of the sensory nerves into a centripetal impulse which passes up to the spinal cord by the posterior root, and is then carried by relays of cells with their axons to the touch centre of the cortex, where it becomes converted into the sensation of touch.

When a wide view of the body and its functions is taken, the nervous system appears as the master structure, and all other organs and systems of tissues its servants and protectors. The organs of sensation supply it with information from outside, the digestive and circulatory machinery supply nourishment, the various glands secrete and excrete for its benefit, and the muscles carry out its commands. All function of the nervous system, every mental and psychical action, comes to light only as a muscular performance. The grandest ideals, the noblest thoughts, can only be expressed by words, which are actions of the articulatory muscles; or in writing by the hand, or in gestures by movement of other muscles.

Hughlings Jackson, who might be termed the Darwin of the nervous system, has shown that all nervous action can be analysed into a sensation, something impressed on a sensory nerve end, and a movement. Whether the sensation be pressure on the skin, slight chemical changes from light falling on the retina, or mechanical from vibrations of the ossicles in the ears, the sensory impress causes a nervous impress to travel centripetally to a sensory nerve cell S_1. Through the cell dendrons this impulse spreads to neighbouring cells A_1, which again react on, for instance, a near motor cell M_1; an impulse travels centrifugally down its nerve to set some muscle fibre in action. This represents the simplest kind of nervous action, and need not be accompanied by consciousness; indeed, such an action is generally quite unconscious. This type of nervous machinery has an ancestry so ancient, and heredity so fixed, that it descends to all in similar and unvarying form, causing mere muscular response to a sensory irritation which is known as a **reflex act.**

But the sensory cell S_1, of which there are myriads, representing every element of body area and surface, is in connection not only through A_1 with the dendrons of other neighbouring motor cells, as M_1, but also itself

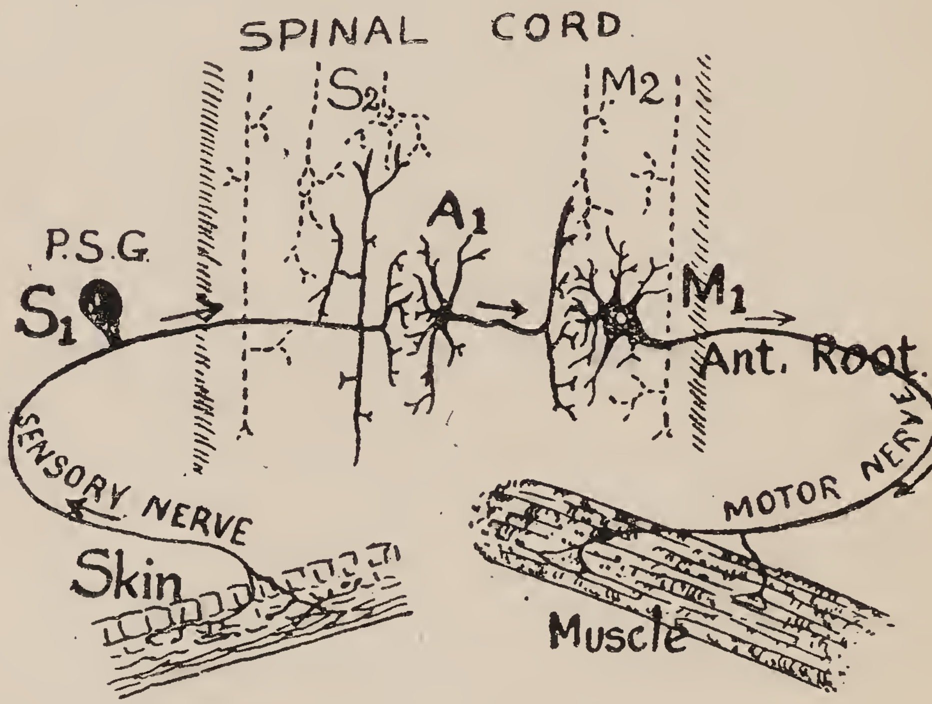


FIG. 1.—Scheme of simplest elements of nervous action: a reflex arc.

The nervous impulse set up in the sensitive surface (skin, etc.) travels up the afferent (sensory) nerve to the sensory cell (S_1) in the posterior root ganglion (P.S.G.), thence to ramify in the central nervous system (spinal cord, brain). This cell may set up activities by its discharge in the association cell (A_1) or in other sensory cells (S_2). The cell A_1 can again activate motor neurones, of which the nearest (M_1) is shown. These can also be activated from the brain through motor neurones (M_2). From M_1 the motor impulse passes out through the anterior root motor nerves to set the muscle in action. The route S_1 A_1 M_1 is a reflex arc, the simplest route which can be taken by the nervous impulse.

with prolongations of other more central sensory cells S_2, of a higher grade functionally, as they receive and integrate impulses from many sensory cells on the functional level of S_1, so that in place of small elements of sensitive surface, such as each cell represented, there are considerable districts, and the nature of the most complicated impulses received by them can be analysed out by these higher-level cells. They again are in relation through very numerous association cells A_2 with correspondingly higher-level motor cells M_2, which affect movement not of a single fibre or muscle, but through the many lower motor cells M_1 which they each control can group fibres or muscles so as to give complicated movements. This higher set of sensory, association, and motor cells is known as the second, middle, or intermediate level of Jackson. They subserve the organic functions of life and complicated automatic movements, generally acting subconsciously. These second-level cells are likewise of ancient ancestry, although evolved later in race history than the lowest-level cells which they control: they have long heredity and develop early and easily, so that they are liable to little change or imperfection, developing thoroughly under the normal stimuli of life, unless, as is common with town children, early life is passed under conditions wanting in sufficiency of such physiological stimuli.

Just as these second-level cells co-ordinate and control groups of the lowest-level cells, taking their sensory impulses and converting them into motor impulses of a complicated nature, so the whole actions and reactions of this second level are again represented in an infinitely more complicated way and brought under wider control by a third or highest level of cells S_3, A_3, and M_3, whose control and action are within the conscious life, in its widest sense. This highest level is comparatively lately acquired, and is itself much stratified, if such a phrase may be allowed, so that some functions are ill-developed, others only a few can attain, whilst even such common things as reading and writing many fail to reach, and the average moral level of behaviour is impossible to a still larger number. It is this comparatively late development of these highest functions, and the fact that they are not fixed by long heredity, that make the effects of education valuable. It is, indeed, only

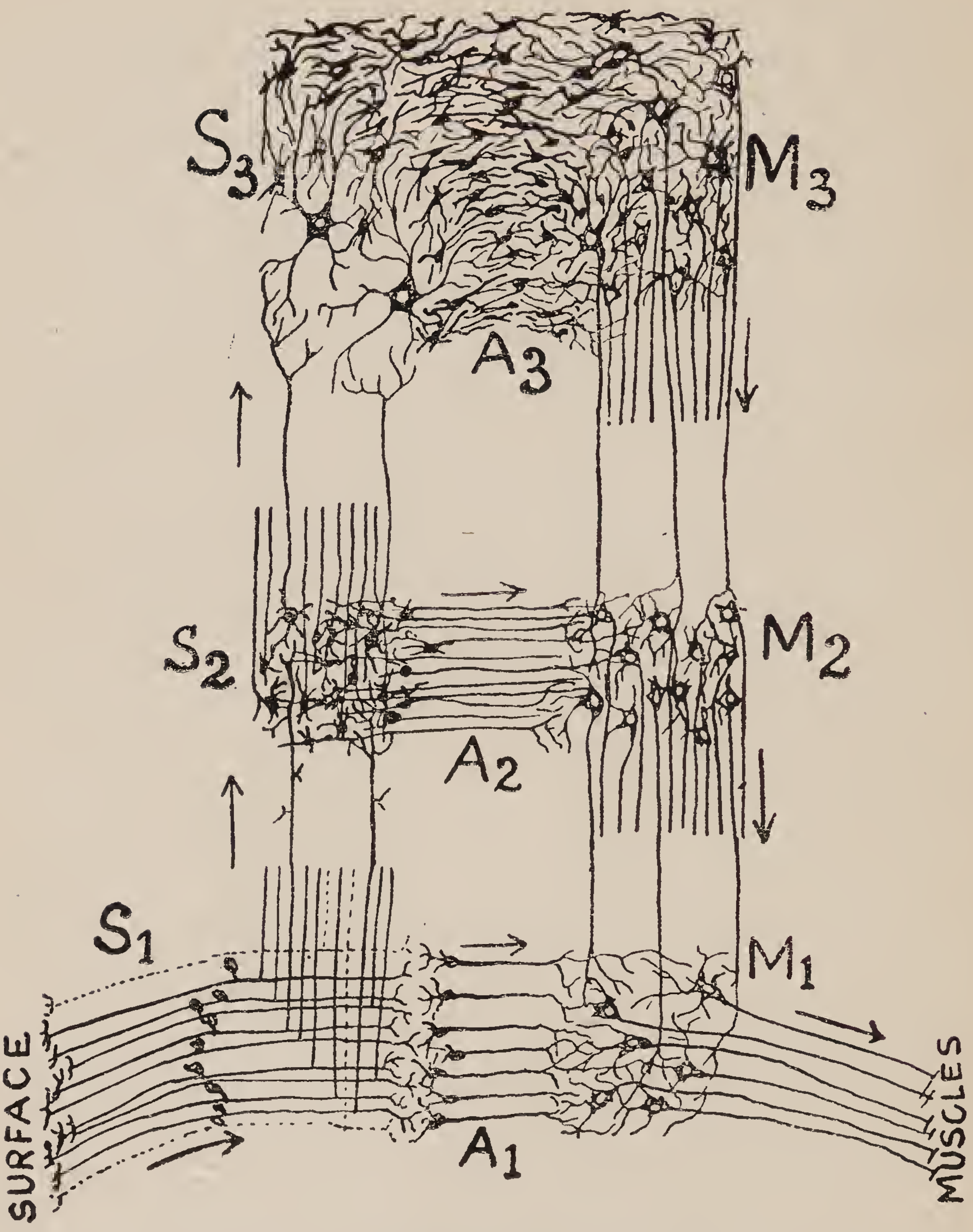


FIG. 2.—Diagram to illustrate general structure of the central nervous system.

A nervous impulse originating at the surface passes up to the first-level sensory cell (S_1) and then on, either through the simple low-level association cells (A) to the motor cells (M_1), causing a reflex act, or it goes further to the second-level sensory cells (S_2). Only two nerves are continued in the diagram. The impulse at S_2 may pass through a variety of second-level association cells (A_2), setting in action one or more motor cells (M_2), which again control groups of M_1 cells, producing complicated actions; or the S_2 cells may set the highest level (S_3) in action, and here, through an infinite variety of associations, A_3 may produce the most complicated conscious actions.

in this highest region of the nervous system that any real educational improvement is possible. The highest human attainment is self-control, which can only be secured by the perfect functioning of these cells which control all activities.

From Hughlings Jackson's conception of the three levels of nervous function, it follows that a record of the animal's evolutionary history is embedded in the structure and workings of its nervous system, just as the earth has its geological record, and that the more recently developed functions are the highest and latest acquired.

That these are also the least fixed by heredity, and most likely to vary in degree of development and in liability to injury by adverse causes, will be frequently noted in later chapters. This scheme of nervous function and machinery as traced out by Hughlings Jackson has been like a search-light in making clear the fields of both medicine and education. It may be recapitulated, that the order of evolution of the nervous structures in the animal world appears to be that the lowest levels are the first to develop and function, both in the race and the individual. The highest levels, least fixed by heredity, and most subject to environment and education, are those which appear latest. The reverse order is followed in dissolution of the nervous system, whether from the slow effects of disease or the action of general poisons. Alcohol, the most universal protoplasmic poison, picks out and paralyses the finest and latest developed qualities first. The keen edge of the judgment is blunted earliest, then slight loss of control of the speech centres is shown by loquacity; finally, as deeper stages are reached, the middle-level functions fail, the balance of the eyes is not maintained, things are seen double; then the control of the limbs fails, till at last the lowest levels may be attacked, and finally even such automatic mechanisms as are necessary for life may give way, and at last the breathing ceases. Again, a child who is just beginning to walk or to speak may easily have the nervous development connected with these functions delayed and thrown back for a time by some childish illness, and even temporarily, as every mother knows, the highest qualities may be thrown out of gear, and childish tempers and moral lapses may occur from toxic hindrances which are amenable to treatment by castor oil.

Nutrition of the Brain.—Whatever view be taken as to the exact relationship between mind and brain, it is agreed that the brain is the instrument necessary for all mental operations. The nutrition of the brain depends upon its having a supply of blood of good quality. Thus any constitutional weakness associated with feeble circulation or anæmia (impoverished blood) will impede or embarrass the mental functions. The effects of alcohol have been described; similarly deleterious materials may be absorbed and give rise to listlessness, apathy, or other nervous symptoms. The headache associated with indigestion, excessive tea-drinking, or habitual constipation is notorious. On the other hand certain materials seem necessary for brain development. The thyroid and some other ductless glands have powerful effects, and insufficient thyroid material in the blood of infants is associated with an arrest of bodily and mental development known as cretinism.

Mental activity is accompanied by an increased flow of blood to the brain, and with increased flow of nutritive material the brain grows. Hence, within limits, reasonable mental activity produces increased mental power.

The improved circulation and better quality of blood produced in the pupils of the open-air schools are, as a rule, soon revealed in faces expressive of happiness, interest, and curiosity. The alert nervous expression in the face of a child ought to be looked for as the result of all good training and sound education.

Heredity is the main determining factor of potential mental qualities, but education can help the development of these potentialities, and in greater proportion the higher they are in function. Different convolutions of the brain have special functions, and disproportionate development of any one part may be produced by excessive mental activity in a particular direction, with the result that the cultivation of one sensory organ, or rather the corresponding part of the brain, may be encouraged to the neglect of other senses. Each sense requires special cultivation, and develops its potentiality in proportion to the skill used in the educational process.

The relation of all parts is intimate, and imperfect performance of one function may react on many others. Comparative studies have shown, for instance, how with development of the powers of the fore limb and hand in different animals there is development of the field of vision, and that the region of the brain subservient to vision, the so-called *visual cortex*, develops correspondingly in mass and complexity. Indeed, the hand and eye might almost be regarded as one organ in the sense of nervous function.

The muscular sense and common sensation develop at a very early age. The suckling stretching and moving its limbs, twisting and boring about, feeling and handling its nose and ears, wrists and toes, is educating itself in these respects. The sensations derived from movements (*kinesthetic sensations*) of eyes, lips, tongue, body, and limbs are all of value in estimating distance and space. This kinesthetic sense is one of the earliest developed, and has great potentialities and refinements which often are allowed to remain latent. Reliance mainly on this enables the Montessori methods to attain certain results at an unduly early age. The possibilities of this muscular sense are also seen in the willing game and thought-reading. Although such possibilities exist in all the senses, yet it is quite probable that the effects of formal education are much overrated, and in regard to mental training it is highly probable that in the elementary school the amount of class instruction goes far beyond the power of the child's assimilative capacity, and that only a fraction of such instruction benefits the child.

Recent theories of the structure of the mind tend to the idea that from the very earliest years ideas and desires, buried in oblivion, are absorbed and elaborated with vast influence over the future life. These ideas and desires have to be built into a harmonic structure. Sometimes these, not being in accord with the conventions of civilized life, are repressed without being assimilated, so that they exist quite unknown to the individual, but possibly influencing other ideas or conduct. The mental life of an individual which emerges into the clear light of consciousness is rigidly balanced and bound up with a great mass of hidden subconscious mentality, just as the shimmering pinnacles of an iceberg, glistening in the sun, are oriented and swayed by nearly ten times the mass of similar solid material beneath the surface of the sea. Hence the reason for insisting on all the amenities of life possible in the schoolroom. The children have longer vested interests in the country than any adults, and the very youngest child is a citizen for whose future life the country should do its best without fear or compromise, even in the sense of cultivating its earliest ideals towards the highest and best things. Hence also the vast importance socially of proper education among its fellows, even in the infant department and baby-room.

Certain **automatic movements** occur independently of any immediate disturbing influence from without; such are the movements of respiration, which are controlled by the nerve cells of a centre situated in the *medulla oblongata*, the portion of the brain in anatomical connection with the spinal cord. This respiratory centre is a mechanism of the lowest nervous level, and is set in action by stimuli derived from the amount of carbon dioxide in the blood.

Complex acts such as walking or writing, which belong to the middle levels of performance, require in the first instance to be learnt, slowly and with great pains, under conscious control. All the children in the baby-room should be taught to walk along a one-inch board set on edge. During the process of education and development these middle-level acts are delegated to the control of lower centres and are performed subconsciously, but they are never automatic in the sense applied above to respiration. Slovenly and clumsy acts, if allowed to be repeated, may become fixed as such in the nervous system, and when groups of cells have thus become associated together to represent these acts it is too late to correct the fault. This is often noticeable in speech, when the precise articulation has not been imitatively acquired by a child, who, indeed, is often defective in other respects. It is while new accomplishments are being learned, whilst the nervous mechanism is still plastic, and still being guided with a conscious effort, that constant and assiduous care on the part of the teacher must obtain. Prevention is nearly always possible, cure almost never. Memory of all kinds depends on a pathway that has once been used being thereby easier for impulses to travel along again. The oftener the pathway is used the more fixed it becomes, and the greater likelihood of nervous impulses travelling that way. Thus are formed habits good or bad. Habit is memory chiefly of the middle-level centres. "The great thing in all our education is to make our nervous system our ally instead of our enemy. It is to fund and capitalize our acquisitions, and to live at ease upon the fund. For this we must make automatic and habitual, as early as possible, as many useful actions as we can, and guard against growing into ways that are likely to be disadvantageous to us, as we should against the plague" (William James). "Think twice before you speak," says an old preacher; but the man of action who is to be a force in the competition of everyday life should be able to speak without needing to think, or rather he should have thought to such purpose in the past that it is unnecessary now, and the correct reply comes at once almost without conscious effort.

To summarize:—

Studies requiring observation, memory, or reasoning bring into action different parts of the brain, and each requires careful and balanced attention. The utility of a brain depends largely upon its readiness of response to stimuli. Corresponding to each thought there is a nerve current in a particular part of the brain. Nerve currents travel most easily in the pathways of least resistance; that is, where currents have repeatedly passed. Hence, careful and persevering attention to the formation of good habitudes of thought will strengthen individual character. In this way a wise teacher may help to counteract evil hereditary tendencies or newly acquired habits of an objectionable character, and thus aid in the formation of a strong and evenly balanced mind.

The four chief means for the development of the nerve cells are:—

1. Afferent impulses reaching the brain from the different sensory organs;
2. Efferent impulses passing from the brain to initiate muscular acts or to cause their repetition;
3. Functions of association between the two above, as, for instance, when a lesson dictated by a teacher is

being written down. Here the afferent impulses are received by the ear; the efferent are transmitted to the muscles employed in writing.

4. Co-ordination of efferent impulses to produce harmonious action of a complex character. Thus, in reading or writing the necessary co-ordination of the muscular movements involved is chiefly effected by the nerve centres at the base of the brain and in the cerebellum.

CHAPTER II

SPEECH

THE intellectual life of man is closely associated with his power of speech. With the development of this faculty definite centres become organized in the brain. These speech centres are mainly four: the *auditory word* centre,

FIG. 3.—Location of chief speech centres on the left hemisphere of the brain.

A, auditory; V, visual; W, writing; S, speaking.

the *visual word* centre, the *motor speech* centre, and the *writing* centre. In most people they are on the left side of the brain, but this is reversed in left-handed people. Behind all these centres stands some co-ordinating, judging, and regulating mechanism which we associate with the intellect. For this intellectual centre no locality can be assigned, although large areas of the brain are known to be associated with all the other centres and to be the latest to attain full anatomical development. They are spoken of as the higher association centres.

The Word Heard and Spoken.—The appreciation of sounds heard would represent the earliest part of the speech faculty developed in the history of the race, and thus the hearing centre and the intellectual appreciation

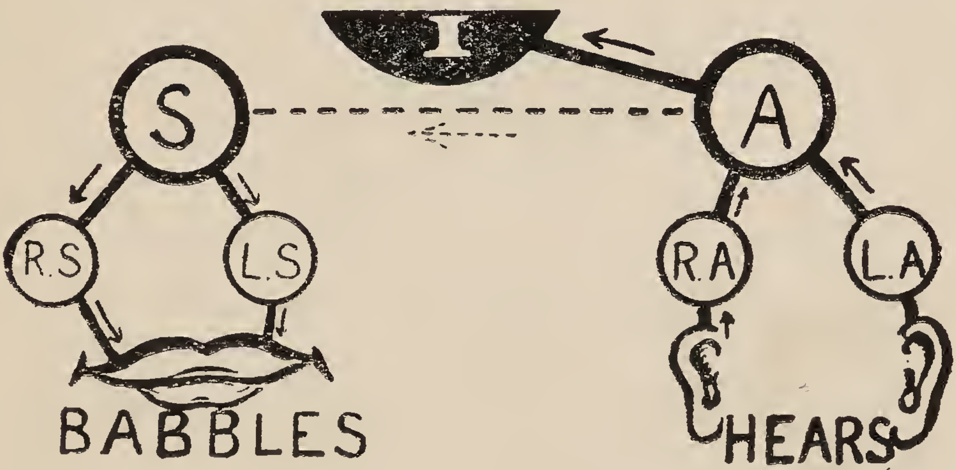


FIG. 4.—Diagram of speech centres in a babbling infant less than a year old.

Dotted line indicates the connection developed when echolalia appears. R A and L A, the lower auditory centres. A, the auditory centre. S, the motor speech centre (Broca's); and R S and L S, the lower speech centres. I indicates the higher centres of association concerned with intellectual control.

of its message would be first developed. The infant reacts to sounds by movements; it begins to hear when a few weeks old. Each ear is connected through its auditory nerve with a hearing centre on the same side of the brain. These centres again are connected with the one word-hearing centre, and through this with what may be called an intellectual centre. As the word-hearing centre develops the child begins to understand some words spoken to it, at about nine to twelve months old. The word-hearing centre and its connection to the centre for intellectual appreciation, so far as words are concerned, are therefore by this time partly developed.

Meanwhile the infant has been producing babbled sounds meaninglessly for some time. This babble is the first starting of spontaneous function in the developing motor speech centre, and as yet has no real meaning, and no connection with the intellect. It is caused by the motor word centre preparing for function, setting in action the speech muscle-controlling centres on both sides. The next stage is of great interest: the child is noticed in the midst

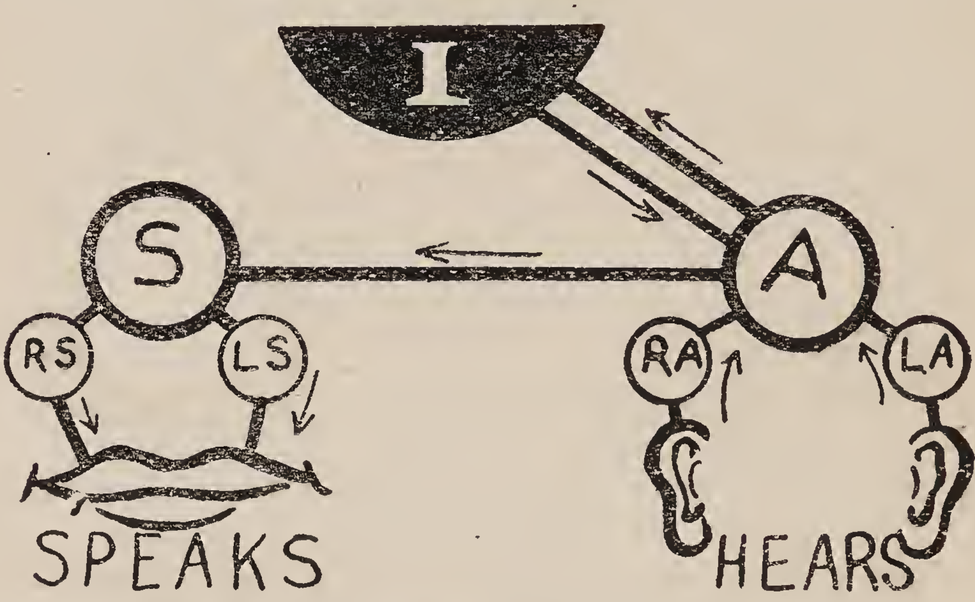


Fig. 5.—Main centres, hearing and speaking, in an illiterate person.

of its babble to repeat occasionally a word it has just heard, and later perhaps several words—mere repetition without meaning, termed *echolalia.* The connection shown by the dotted line in Fig. 4 has now developed between the auditory word centre and the motor word centre, and the former (auditory) is setting the latter (motor) in action, without the intellectual centres taking any part. Normal at this infantile stage of development, in the adult or school child echolalia implies the existence of well developed lower brain centres and want of their control by the higher mechanisms. Like any other sign of irregular order of mental development in school-life, this suggests feeble-mindedness. In the midst of the babble and echolalic speech, words begin to be used with meaning as intellectual growth develops paths to control the motor centre. The babble gradually ceases as the intelligence develops control of the motor centre, and intelligent speech of a rudimentary character appears. Often the speech is thought to be more intelligent than it really is, phrases being used as heard, and, indeed, the intelligence of young children is generally much overestimated. The speech even of adults, if uneducated, may remain largely dependent on words heard, so that frequently the staple of their speech is a gossipy repetition of others' remarks, "says he," "says she," "they said" forming a kind of echolalic *résumé* of conversations instead of an intellectually digested narrative. The earliest speech is naturally very bald—mere nouns and verbs; to the infant every man is "Daddy." Refinements and qualifications come later, the personality of the speaker not being recognized for some time. The language used in describing a picture, as a sidelight on intelligence, forms one of the most differentiating tests of the mental level of a child in its earlier school years. The profound effect of good education in the mother-tongue is scarcely appreciated in school, being largely postponed until puberty, when the general adjustment of mental values comes and characteristics such as handwriting are formed.

Other hearing centres also develop, and where the intellect has to concentrate on the interpretation of certain sensations great acuteness may be gained, as in the case of the trained musician or of the blind person who interprets sounds with much discrimination.

Printed and Written Speech.—For the majority of human beings in the past the whole of speech was spoken or heard. No doubt signs and gestures helped out early speech more than they do now. Their antiquity is shown in their general utility among all races. Sketches by cavemen show how early graphic records of things and deeds were attempted. Pictographs followed, as in the earliest Egyptian hieroglyphics. The cuneiform inscriptions of the East, which stretch over a longer period of time than our own alphabets, were highly conventionalized pictures. European alphabets have developed from hieroglyphics. The conventional alphabetic signs nowadays, being without intellectual content, must be learned through all

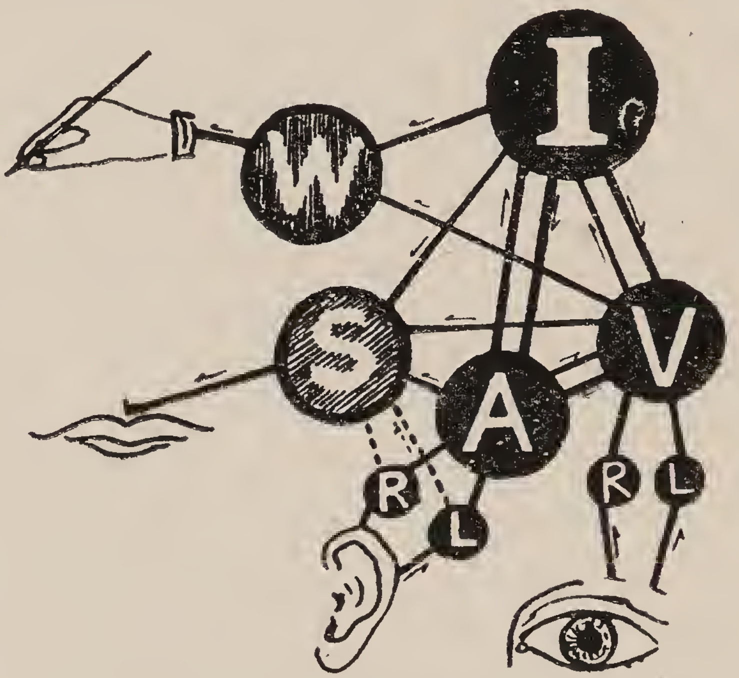


Fig. 6.—Main centres in a literate person.

V, the word vision centre, with its lower (R and L) centres for each eye, and W, the graphic centre.

possible senses. The average infant-school child learns letters and forgets them in half an hour. Words are recognized both by their letters and by their general form. The beginner spells out the word, recognizing each part of every letter, but the practised reader sees the word form as a logogram. The memory of this word-image is stored up in the visual word centre. The mode of recognition of a word seen is on a similar plan to a word heard. An image of the word seen by the eye is transferred to the visual brain cortex of the right and left occipital lobes, and from there to the word vision centre in the left angular gyrus, whence it reaches the intellect to be apperceived. From this intellectual centre the motor centre may be set going immediately, as in reading aloud, or more remotely, as when the old man recounts the talk of his boyhood days. Occasional mistakes of children hurriedly reading are the substitution of words pronounced for those seen, e.g. "up" for "down," "monarch" for "king," "stick" for "staff," showing that there is this still higher centre, beyond the mere seeing and hearing mechanisms, exercising a choice.

Words Written.—A centre for writing movements is generally postulated in the same region as the centre for the right hand muscles. It is a centre for motor memories of word forms, and develops soon after or almost with the visual word centre. Here again written speech, much later developed in the history of the race, is also later acquired by the individual. A considerable number of people, too, are still so unevolved as regards these centres that they will never be able to make fluent use of written or printed speech. At least 2 per cent. of the elementary school population never attain intelligent use of this function. Probably 5 per cent. will never give a return for teaching, and any number up to about 10 per cent. put it to so little use in later life, beyond signing their names, that prolonged attempts at literary education exclude time for more useful knowledge.

Development of the writing faculty in the child begins by spontaneous attempts at drawing, at first mere meaningless scrawls, followed by recognizable but strangely conventional drawings. Education of high value and clear thoughts are bound up with this expressive work. A stage of mimic reading comes, when the little body delights in pretending to read or in scrawling mimic epistles.

Ultimately, at about four years of age printed letters appear almost spontaneously, usually capitals, then the name, often with many or all the letters reversed. Some of the earliest inscriptions known are written from right to left, as many Oriental languages still are. Later a period with alternating direction of lines follows, this stage being often seen in children who print alternately normal and reversed, as a step from the mirrored to normal. In a few cases, often in feeble-minded, mirror writing persists till quite late in school-life. In ordinary schoolwork a simplified script would perhaps be the simplest to begin the teaching. Capitals are used generally by children who pick them up early by imitation or from others in the family.

In addition to these main forms of speech memories, knowledge is also got from actual memory of the speaking movements. In the deaf this is developed as a visual memory for lip-reading, and every one lip-reads to some extent; but usually hearing and word vision preponderate, and one more than the other, so that individuals may be classed as visuals or auditives. The visual, commonest after nine or ten years of age, gets most knowledge from reading, pictures, and maps; the auditive, commoner at earlier ages, from speech, conversation, and lectures. Sometimes in a bus or tram people can be seen reading the papers and helping out a defective word vision centre by the lip movements of silent reading. They are either badly educated visuals or strong auditives who have had to call in the kinesthetic sense (combined movement and feeling) of the muscular action of the lips. Cases with poorly developed word vision centres may not be able to learn to recognize words, and there are all varieties from mere congenital bad spellers to actual inborn word-blindness. Although congenital bad spellers are so common that almost every school has one, bad spelling is more commonly due to bad teaching than to this defect. Spelling reform is a most necessary thing merely to relieve the burden on the English learner. Perfectly normal ordinary vision is the rule in all these cases, even when congenitally word-blind.

The auditory word centre, being much earlier in individual and racial development than the visual centre, is not nearly so liable to physiological variation. Congenital word-deafness, without deafness for other sounds or music, exists, but it is extremely rare. It is important to recognize this, as such a child may be quite intelligent and yet cut off from all human knowledge. In the past cases of this kind have been treated as imbecile.

An interesting exercise may be suggested here to the student, that is, to attempt to chart out the various used and unused paths and centres involved in spontaneous speech. Copying from a book, silent reading, reading aloud, writing from dictation, the conditions of congenital word-blindness, congenital word-deafness, learning to read by word-building or by the phonic system, and so on, being worked out by diagrams, the knowledge will be of great utility later to those who have to teach such subjects.

The child usually learns letters as a muscular memory, hence the bigger the letters the better. Letter-blindness, being helped out by muscular memories, is very much rarer than word-blindness; single signs, Arabic numbers, and all combinations of figures are generally well recognized. A child who failed to learn letters knew some gipsy signs, and a capital delta—Δ—meant to her "They have a dog there." The word-blind can nearly always write their own name correctly; it is a logogram to them, and the equivalent of a single sign.

Defective Speech.—Slight speech defect among younger children may be regarded as physiological retardation. Many children, however, after passing through the standards, at the age of fourteen leave school and still express themselves in such crudely formed language and with such defective enunciation that they can only be understood with difficulty. Cases are noticed of imperfectly formed or substituted speech, as lalling or lisping. There is a comparatively rare form where the individual speaks so rapidly and with such badly formed sounds that they are nearly unintelligible. Other cases present mechanical defects, as cleft palate, nasal obstruction, adenoids, and so on. Idioglossia, where the child appears to speak a language of its own, is seen in young children occasionally who have not learned their elementary sounds properly.

Stammering.—This is the commonest defect, and considering its serious effect on the child, it is still strangely neglected by educational authorities. Stammerers are as numerous, and probably a hundred times more valuable nationally, than the class of feeble-minded on whom so much effort and cost at present is almost wasted. About a half per cent. of girls at all ages, and from a half per cent. of boys in infant schools to 3 or more per cent. of boys in the top standards, are to be counted as stammerers. It is purely a functional nervous disorder. Family predisposition towards nervous defects, and particularly stammering, is the chief point noted. Shock, accidents, or illness frequently bring out, and sometimes improved general health appears to diminish, the tendency. The defect appears more common in Germany, where the people are notoriously nervous, and where it seems to be developed by the forced articulatory explosive manner of producing consonants taught in school.

Suggestion or imitation will also sometimes bring it out. The educational methods of treatment by various breathing and vocal exercises are largely imitational and suggestive, and depend greatly on the personality of the teacher, who can make almost any method a success if he is firmly persuaded of its value. A stammerer should have his vocal sounds analysed, so that he can be shown where his difficulties come. The vowels being voiced are scarcely ever a source of trouble; it is on voiceless explosive sounds associated with the maximum articulatory effort, like P, T, K, that the commonest stumbles are made, but in special cases any of the consonantal sounds may be found troublesome. It is a functional disturbance, as the machinery of breath and voice is complete. There is rarely any hitch in singing, for the stammerer can usually intone, and often an after-dinner speech is faultless. Many have acquired bad habits, speaking, for instance, from an empty chest. The stammer itself is mostly exaggerated articulatory effort. The analysis of voice sounds and their articulatory mechanism is much aided by using a physiological alphabet for consonantal sounds, such as that of Dr. J. Wyllie.

Consonants.	First Stop Position.	Second Stop Position.			Third Stop Position.
	Labials.	Labio-dentals.	Linguo-dentals.	Anterior Linguo-palatals.	Posterior Linguo-palatals.
Voiceless Oral.	P	F	S Th	T Sh	K H or Ch
Voiced Oral.	B	V	Z Th*	D Zh L R	G
Voiced Nasal.	M			N	Ng

Voiceless *Th* as in *Th*in, the voiced oral *Th** as in *Th*ose.

If, then, stammering is taken to be a nervous incoordination in the oral and laryngeal mechanisms, with excessive articulatory efforts without properly voiced sounds at the same time, it can be regarded as a habit rather than as a disease. It can be cured, obviously, by any means of breaking the habit. This may be sudden, as by hypnotic suggestion, or gradual, by instruction and cultivation of other habits of articulation and voice production. Every teacher can manage to make the stammerer sound all the vowels and allow him if necessary to elide consonants. When by the physiological alphabet and test sentences the difficulties are known, these difficulties can be avoided at first and gradually led up to and ultimately overcome.

It is bad to draw attention repeatedly to stammering, or to give any punishment, or to frequently test the pupil with the view to see how he is progressing. These methods actually give suggestions in the direction of harm, and tend to undo the benefit of any remedial education. The pupil's extremely conscious efforts at the details of speech have to become imitative, then automatic, and finally entirely subconscious, before any cure is attained, and therefore the less the attention is directed to faults the sooner the habit will be broken.

Left-handedness.—The two hemispheres of the brain are each intimately related to the opposite side of the body. The peculiarly human faculty of speech, as already seen, has its brain centres generally in the left hemisphere, where are also the centres for the right hand. From 4 to 5 per cent. of people show some degree of left-handedness, and in rare cases, through the results of disease in later life, the speech centres are found to have been developed on the right side of the brain. This sinistrality is of deep origin, running through all nervous actions: the left foot will be used to kick with, the hair will be parted on the opposite side to that which is usual, the left eye will be used mostly in fixing objects, and so on. Such tendencies are inborn, often strongly hereditary—the "Kerr-handedness" of Scotland—and manifest themselves in the earliest years. More boys than girls are sinistral, and the numbers diminish during school-life. A very few children are ambidextrous, but this is generally from want of sufficient development of one side, so that they are usually otherwise backward and really ambisinistral. A left hand writing in normal script goes thumb first, not thumb last, as in the right-handed, and if the anatomically corresponding movements of normal writing are made with the left hand, a reversed script—mirror writing—is the result. Indeed, to a normal person using the left hand, mirror is easier than normal writing. Mirror writing with the right hand is occasionally a stage in ordinary childish development, but often persists till late in dull or defective children. For children over ten a test of setting them to write with the left hand has been proposed, and it is found that the dull ones rarely make the necessary adjustments, and write mirrorwise. It is often asserted that left-handedness predisposes to stammering, also a hereditary flaw, common in boys, but increasing during school-life. A direct association is probably not real, although it is stated that attempts to make sinistrals use the right hand tends to develop stammering. It is worth while attempting in school to bring the young left-hander to practise right ways, considering that tools and traffic arrangements in our busy life are all devised for the right-handed, but the attempt might prove mischievous in very marked cases of sinistrality.

Ambidexterity.—This has been advocated as an educational aim, but except as a variation in free arm drawing in very early life, which perhaps may help to a wider space perception, it is to be regarded as purely a crank, if not actually harmful and time-wasting.

CHAPTER III

AGE AND SEX IN RELATION TO SCHOOLWORK

Age has a most important bearing on the character, amount, and distribution of the work to be given to children. During the period of *childhood*, including up to the end of the seventh year, more rapid changes are taking place than at any subsequent period of life. At seven years old a child weighs about six times as much as at birth, and has more than half the stature and one-third of the weight of an adult, while its brain at the same age has attained nearly its full size. This does not, of course, imply that it is fully developed. Practically no book work should be attempted during this period. Education is not confined to schools. From the first moment of life education in the best sense commences, and makes rapid strides. The senses become trained, and the powers of observation are perhaps keener than at any subsequent period, while the mind is becoming stored with impressions which form the groundwork of subsequent mental life.

Capacity for Training.—In the simplest discussion of the training of a growing child, the unit for consideration is the nerve cell, which comprises the cell body and its short processes the dendrons, its long process the nerve, the whole structure being called a neurone. All actions are the result of functioning of neurones, which again results from some stimulus reaching them either directly from sense organs or indirectly through other neurones.

The individual cell, which at first is incapable of functioning, with growth develops so that it can produce certain effects in a crude way, not reacting promptly to a simple stimulus, but along with numerous other neurones in its neighbourhood as the result of some strong stimulus which also influences these to a greater or less extent. Irregular badly controlled and inco-ordinate movements result, with consequent rapid exhaustion, the cell being as yet too immature for economical and effective education.

At a later stage of growth, development is much aided by occasional exercise, and the neurone is capable of exact functioning, then attaining the condition for most effective education, but still undergoing comparatively rapid exhaustion.

With full growth the neurone should be capable of long continued and exact work, and in this stage is mature. It has now passed beyond the need or possibility of further education, and to work it with this view is wasted effort.

The neurone best suited for educational development should be frequently but not too continuously worked, for when benefiting educationally it is undergoing fatigue. Even a very immature cell can be educated, but it is at the expense of wasteful training and rapid exhaustion. There is no royal road to learning, and efficient education always implies the exertion of effort and the production of fatigue, but should never be exhausting.

Order of Development of Nerve Cells.—The cell groups pass through these stages at different times. The first neurones to attain maturity represent the earliest acquired reactions, which are those oldest in the history of the race, reflexes inherited from time immemorial; next the largest and coarsest movements and crude sensations, which are most permanent, soon attain maturity, and are least amenable to education. The finer muscular movements of the smaller muscles, lastly of the fingers, and the finer indications of the special senses come later, about the middle of school-life, and are most capable of training by educational methods in the first half of school-life. The complex co-ordinations which are practised during school-life become as mature actions almost unconscious reflexes, e.g. the mechanical part of reading and writing, the pose of the head and carriage of the body. The complex interpretation and intellectual appreciation of sights and sounds are very late acquirements, and pass into the fully educated condition in the last half of school-life, and during the next ten years are still capable of educational development, and, so far as relates to the highest functions, for many subsequent years.

In the last half of school-life, in the widest sense, the higher intellectual co-ordinations of sensations and movements are being grouped into the most complex ideals and memories.

To attain this end the highest intellectual centres require to be educated by hard work with conscious mental effort.

At the age of three the child may be taken to have learned to stand and walk. It may at this age still require to have these co-ordinations trained. Coarse muscular exercise in moderate amount and frequently repeated daily for short times, as marching, hopping, jumping, standing first on one leg, then on the other, and so forth, are useful forms of training at this time of life. The movements of the eyes in watching distant objects should be chiefly used, and until five years of age only the coarse muscle movements, such as are concerned in running, jumping, and swimming, and those of the shoulder girdle and arms should be definitely worked, and only coarse eye work attempted.

Working with Small Objects in Infant Schools.—If children in the infant school are allowed to work with small objects they cannot possibly be prevented from forming the habit of working at too near a distance; and if they are allowed to do fine work it is impossible for teachers to make them sit up from their work. Such work also implies fine finger work, and the nerve groupings which are concerned with finger work are so immature that children under six can only do it inco-ordinately and badly and with immense strain and rapid exhaustion (see also p. 151).

Children at this stage, that is, four to six or seven years of age, should never be allowed near eye work or finger work; for such children the only graphic forms permissible are chalk drawing and writing on the blackboard, while work with sand trays, big bricks or sticks, big beads or shells, should entirely replace any finer work. The Kindergarten employment known as "embossing," whereby the area enclosed by an outline on a piece of paper laid on a pad of felt is pricked over by a needle in a holder, is one of the severest strains ever imposed on children. It is fortunately dropping out of use now, but sewing with needle and thread is still allowed.

Nerve strain in practice can be seen at any time in an infant school if a class be carefully observed, without interruption from the teacher. Although Kindergarten embossing is the severest strain, sewing will be quite sufficient to point the way for observation of this kind.

A class of girls under seven set to sew may be placed in a correct attitude, sitting upright with the light falling from behind and from the left. They will maintain this attitude for a period to be measured by seconds rather than minutes. Sewing involves fine eye work; it should be done intuitively almost without the eye, but that is after education; by the learning child, who is often incapable of threading the needle owing to its normal condition of long-sightedness (p. 149), the sewing is done by watching the needle point, a comparatively small object, on a background which does not improve its visibility.

For reasons given the child brings its eyes and the needle within 4 or 5 inches distance of each other, and no teacher can be expected to prevent this in the infant school. But the material is held in the hands, and the mere holding up of the hands long continued is a strain no child can maintain; it therefore crouches so that the elbows can come either on knees or abdomen. The work of managing the needle is fine muscle work for the fingers, and these muscle centres in the brain, being comparatively immature, can only be kept at work by excessive working strain. This excess of effort overflows to adjoining brain centres, and causes through them the continual twisting of body and neck and grimaces which young children subjected to this unsuitable task will occasionally be seen to make, some of course being much worse than others. These *nerve signs* tell of exhaustion and wasteful expenditure of nerve energy. Children showing them are suffering temporarily from the strain of over-pressure, for overpressure is less likely to be quantitative than qualitative. For such children, therefore, sewing involves educational overpressure.

Lower Limit of Age for School Attendance.—English regulations fix the compulsory school age at five, a year earlier than the general European average. Schooling in the sense of purely teaching the three R's is a folly below the age of six to seven. Although Madame Montessori has demonstrated the possibility of a mechanical acquaintance with work which constitutes the tools of education at quite early ages, yet the child who learns to read without understanding is more likely to hate than love literature in later life. It is argued, however, that children at early ages cannot learn efficiently. This is entirely wrong, provided suitable courses and occupations are prepared for them. Children have nearly learned a language before entering the school, and learn more in the years three to five than in the same space of time at any subsequent period. The attempt to get work out of non-existent organs, however, will mean failure, and even immature tissues may and do suffer. Precocious work in plastic childhood probably hinders the due course of development and tends to mediocrity of later and higher functions in full age. The remedy for the ills of early and unsuitable schooling lies in a modification of the work in infant schools—in the rigid avoidance of literary work below the age of six; in the teaching of habits of cleanliness, respect, and courtesy; and in the training of developing muscular and sensory functions. Play, exercise, sleep, and food, with good articulation and correct expression of meaning in actual speech, are the chief things here. Nutrition is the be-all and end-all of the child life before the age of seven, to which other things must be subsidiary.

A weightier objection to infant schools is that they propagate disease and death by spreading such childish affections as measles, whooping-cough, scarlatina, and diphtheria. In country districts this is more influential than in town. There, too, wet feet and the winter season may have additional risks, making school not worth while to the country youngster. Every child requires to gain as much protection as possible from these zymotic diseases, but general experience shows that measles, for instance, occurs on an average three or four years later among better-class children than among the poor, although all classes use schools. Even apart from risk of infection, large schools for young children should be replaced by smaller and more home-like centres, where the child could develop its individuality, instead of feeling merely a unit in a herd. Small schools or crèche schools, to be efficient in this way, would be comparatively expensive, as they should not accommodate more than twenty-five to thirty pupils. Apart from expense, they are so desirable educationally that they may be said to be almost a necessity.

It might be desirable to fix limits not only of age, but also of physique as expressed in height and weight, below which no child should be admitted to school without express medical sanction.

Physical Measurements. — Useful information as to whether a child is keeping in good health may be obtained by weighings at intervals of a few weeks. Weighing and measuring at long intervals, as usually done in schools, is, however, of no practical use to any child, and a waste in its cost. Height should be measured in centimetres when the child is standing erect, in stockinged feet, and with the head evenly poised. A measuring rod against the room wall should be used with a sliding rectangular head-piece. The adjustment of the rod is of importance, since errors of a centimetre or more are to be found in rods fixed in schools when they are retested. Weighings should be done to the nearest tenth of a kilogram, in ordinary clothes without shoes. A steelyard balance with sliding weights is best, and it should be frequently tested. These measurements, being recognized as of little value, appear to be done in a most perfunctory way in many cases, as when retested by later work many individual discrepancies are found. If children are being repeatedly weighed a fixed time of day, say between eleven and twelve o'clock, is best. The age in years and months and the date should always be noted.

Other measurements are anthropological refinements, only wanted in special inquiries. Chest girth at the end of expiration and the difference between inspiration and expiration are the most commonly noted as having a bearing on vitality.

The general facts of growth as determined for the English

FIG. 7.—Chart showing average stature, weight, chest girth, and strength of both sexes, from birth to twenty-five years of age, of the general population of the United Kingdom.

Males ———— **Females** ....

population are set out in Fig. 7, taken by permission from the *Life History Album* of Charles Roberts. The next table has been prepared by collating reports of school measurements.

	294,946 Boys.			289,674 Girls.		
Age last Birth-day.	Numbers.	Height. Cm.	Weight. Kilos.	Numbers.	Height. Cm.	Weight. Kilos.
3	9,388	92·4	14·86	8,478	91·6	14·44
4	24,047	98·2	16·29	21,362	98·1	15·82
5	65,438	103·0	17·54	63,825	102·6	17·07
6	20,554	108·0	19·33	21,238	107·6	18·58
7	37,515	114·7	21·20	36,477	113·9	20·50
8	9,684	119·3	22·86	12,014	117·6	22·14
9	7,873	124·7	25·12	8,138	123·7	24·75
10	21,579	129·4	27·42	21,017	129·8	26·71
11	5,084	134·2	29·93	5,129	133·5	29·59
12	37,230	139·8	33·05	36,577	138·7	33·51
13	52,232	142·5	35·15	50,717	144·5	36·31
14	4,342	147·1	38·15	3,702	149·0	39·81

Table collated from about 584,000 measurements of English elementary school children by Drs. Tuxford and Glegg.

This table only applies to elementary school children, and is given to show the way general development goes on; it is of scanty use otherwise, and in particular cases might be misleading. Any figures regarding qualities of school children, especially if intended to be used for purposes of comparison, must always be given with strict regard to age and sex distribution and even time of year. Unfortunately, the millions of facts recorded are comparatively valueless from this defect. In Aberdeen in 1912 the boys of thirteen seemed 4·2 and the girls 5·5 pounds lighter than the previous year, but it was merely dates of examination had not coincided, so that the average ages were considerably altered. The Medical Officer of that city rightly says in regard to the statutory records, "This annual accumulation of figures is a rubbish heap of little value for statistics, and worthless for the purposes of comparison. Till there is some uniformity in method, the time spent in taking measurements and working out calculations is time wasted." The mass statistics of school children published in regard to such qualities are practically meaningless, and it is one of the most difficult tasks to get sets of data regarding heights and weights which are scientifically comparable. Measurements from the East End of London with its alien races cannot be compared for social purposes in any legitimate way with those from North London, nor these again with

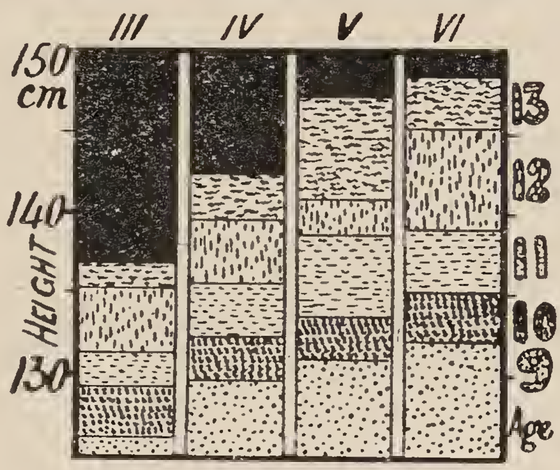


FIG. 8.—Increase of average height with each standard in children of the same age-groups. (Table, p. 50.)

the somewhat different races in South London. A few years ago an attempt to show the effect of care and dieting by comparing ordinary Leeds children with Jewish children in that city was absolutely misleading in neglecting racial precocity. Racial distinctions, and heredity expressed in social levels, must be first eliminated, as they outweigh any environmental conditions. Indeed, physiological precocity of purely Jewish children is so great that they should be handicapped by a year, in scholarship or other tests, in competition with English children.

In regard to children otherwise comparable, height seems proportionate to intellectual development. All analyses show that in any age group the higher the school standard of the children the greater will be their average height. This is, however, only to be taken as an expression of physiological precocity and being generally in advance of the average all round; it is of such interest that the analysis of 4,164 elementary school girls may be given :—

Frontiers of abnormal.	Age.	St. I.	St. II.	St. III.	St. IV.	St. V.	St. VI.	St. VII
140	14–15	—	—	—	—	151·4	153·1	154·2
135	13–14	—	—	136·8	142·8	146·2	148·5	150·2
130	12–13	—	132·4	135·7	139·7	140·8	145·1	145·4
124	11–12	—	132·6	131·1	135·8	138·7	138·9	145·0
120	10–11	125·4	125·8	129·2	132·4	133·5	135·1	—
115	9–10	124·2	122·3	126·3	129·5	130·7	132·0	—
110	8–9	115·9	121·5	123·1	125·2	—	127·0	—
105	7–8	110·1	117·0	117·3	120·0	—	—	—

Average heights of the various age groups, in the different standards, for 4,164 London E.S. girls measured in 1906. First column, "*Paris children.*"

In front of this table a column not strictly comparable with it, and therefore in heavy type, has been put, which was determined for Parisian children by Binet and Simon, and which they term the frontier of abnormality, these limits practically never being overstepped by mentally normal children in Paris, but by possibly 10 per cent. of the mentally defective.

Professor Baldwin, who has made a long continuous study of the growth and school progress of many individual children in two good schools of Chicago and New York, would assess children under five parallel "ages": *Chronological age* in years and months, *physiological age* in growth and maturity, *mental age* in intellectual capacity and ability, *pedagogical age* in school standing, and a *moral or religious* *age.* The last two, however, may only be properly subdivisions of the third. He also finds that the taller, heavier, and physiologically more accelerated children complete the elementary school at an earlier age and with a higher average mark than the short, light, or physiologically backward boys or girls.

The fluctuations in growth differ in tall and short children. Those above the average begin and end their periods of acceleration and arrest earlier than those below; thus the greatest growth increments in height begin at twelve in boys and ten and a half in girls above the average, and continue till fifteen and a half for boys and thirteen for girls, whilst for those below the average the greatest average acceleration in height begins at fourteen for boys and eleven and a half for girls, and continues till seventeen and a half for boys and fifteen and a half for girls.

The supervision of individual children by regular records of height and weight would be of value in many cases and is the rule in invalid schools. They should be charted at least monthly, and this could often be made an interesting and ordinary school subject for the pupils themselves, and serve as a stimulus to health in the home. Any strain will retard development, and the first year of school life usually shows some slowing of growth. Overwork in school may be signalized in this way, and in the Russian High Schools the prolonged examinations have been shown to result in loss of weight for most of the pupils.

Loss of weight is often an early and suspicious sign of the insidious onset of tuberculosis. Illness of any kind, even an operation for adenoids, may mean temporary arrest of growth, sometimes made up by rapid gain during convalescence. Early illnesses seem most effective in retardation.

Co-education.—The general principle of educating boys and girls in the same school classes has not been discussed, as it is largely a matter of pedagogical experience. From the physical reasons already given, whilst up to eight or nine years of age there appears no objection to co-education, above these ages the precocity of the girls comes in, whilst after the primary school age the difference in the work done will emphasize difficulties, especially where pupils cannot be treated individually, but have to be considered in large classes. Except in poorly populated districts with small schools, where it has been an economical expedient, co-education has scarcely had any extensive trial, and there appear no special hygienic reasons to recommend it for adoption.

Crops of Children.—Dr. C. J. Thomas has shown, by measuring children in one particular district, not much subject to migration, that crops of children were found the relatively tallest belonging to years of low infant mortality, and the shortest to years with a high infant death-rate for that district.

Measurements recorded at Rugby, Marlborough, and Manchester show that the present boys are bigger than the generation of their parents. Copenhagen scholars and the conscripts of Denmark, Norway, and Sweden show similar increase in later stature. It is probably accounted for by the general diminution in recent years in infantile and childish diseases having permitted a higher average development. Tables for standards of normal growth should exclude diseased children. The table already given, made up of entrants and leavers with those of an intermediate year, and also the "specials" of other years—that is, children presented on account of some diseased condition—shows no great variation in measure for these last ages. Apparently the conditions for which "specials" are presented are so trivial that they do not affect their physique as compared with the other children, if the total mass has not obliterated all details. There is also obliterated in these tables what is, for schoolwork, practically of greater importance than any of the gross average measures, and that is the seasonal variation in rate of growth. Increase of weight is great in summer and autumn, slower in winter, and almost arrested in spring; heights follow a nearly reverse rule.

The effects on physique of the open-air schools, when held in summer and autumn months only, and estimated by the growth in weight during this period as compared with that of normally healthy children over the whole year, formerly led to an overestimate of the effect of such schools on weight. In an institution where weights were being regularly recorded, loss of weight was asserted as the result of school lunches being started, a result to be discounted as wholly due to this seasonal variation showing up in the spring. Measurements of a school taken in spring and in autumn might thus give different growth curves for the same children.

When a child is growing rapidly in height, probably his powers of mental application greatly diminish; he is dull and apathetic, wants to sit about aimlessly, and perhaps lays himself open to censure which might have been averted if the teacher had noted or considered the rate of growth. During the same periods developmental faults, to be discussed later, such as spinal curvature, flat foot, and short-sightedness, are apt to progress and become evident. On the other hand, during the period of increase in weight, usually the best season of the year, illness is said to lessen and school attendance to be good.

Bowditch, who first made extensive observations, summarized his tables of growth for American children as follows:—

(1) During the first twelve years of life boys are from one to two inches taller than girls of the same age.

(2) At about twelve years girls begin to grow faster

than boys, and during their fourteenth year are about one inch taller than boys of the same age.

(3) At about fourteen and a half boys again become taller, girls having at this period very nearly completed their growth, while boys continue to grow till about nineteen years of age.

CHAPTER IV

THE OPEN AIR.

A GENERATION ago the diagnosis of consumption was almost equivalent to a sentence of death, later the open-air treatment was introduced, and now the outlook for a consumptive is even hopeful.

We no longer sleep in nightcaps. The day of the four-poster bed with its curtains is gone, and although in Scotland the press or box bed still exists, it is vanishing and taking with it a fertile cause of disease and death. The movement for fresh air has extended beyond the consumptive to other invalids and to schools.

It is useful to consider the popular ideas and explanations of the common happenings of daily life, and when these happenings are the result of vague feelings, sensations, emotions, or desires, the underlying ideas are usually deeply rooted in the past. Although two or three generations mark the urban life of the race, and as many hundreds the duration of civilization from what may be called the state of nature, this itself is the result of hundreds and thousands of generations. The ancient man is no more likely to have suffered from colds than other animals, but he gained freedom from risk of other animals' incursions and had a feeling of comfort and safety at the side of a fire. With a solid mass behind him, whether tree or rock or earth, he was no doubt more secure, so that the comfort of warmth and of snugness is joined with a sense of safety and is probably a very ancient relic of feeling, and unobjectionable under the conditions in which it developed, in the open air. The idea of catching cold from night air is a more recent one, associated with populous communities. The "cold" is due to microbes which only get their chance when some of the protective mechanisms are out of gear. Colds are not caught in the middle of the Atlantic, and none of the members during the long night of the last Antarctic Expedition had a cold till a bag of clothing was opened. The history of consumption is similar; tuberculosis was comparatively rare among the fishermen of Norway and Labrador, who had to work in open boats and stoveless sheds, but with the coming of close American stoves to heat their sheds, into which they crowd, and the heated cabins of petrol-driven boats, consumption has increased.

The story of the fresh air comes out indirectly in the Reports of the Registrar-General, where the length of life of each class of the community is seen to be almost directly related to their access to the open air, and if deaths from respiratory diseases only are considered the effect is still more marked. At one end of the scale stand the farmer and the agriculturalist, whose deaths may be taken as 100; shopkeepers, generally, jump up to 150; shoemakers and drapers, who usually follow sedentary work in close places, reach 200; whilst printers and bookbinders, whose low-roofed and stuffy workplaces are notorious, rise to 240.

For countless ages, then, mankind has lived mostly in the open, sheltered by trees or caves from occasional periods of bad weather, but with a history as town or house dweller of comparatively few generations. He is not yet adapted to close confinement, and in the plastic period, during youth, suffers most severely. A reversion to nature—" the simple life"—has been the cry of many philosophers and educators for years, and not without cause; for it is in great cities, where our social system allows a few to hold the ground, and as rent to take a large proportion of the earnings of others, that the children, especially of the poor, through this suffer physically to an enormous extent. Air is a necessity, as one American writer puts it, which goes with the land, and wherever one man has too much land, others have too little air. It is said that every great diamond has cost much blood, and equally it might be said that every ducal rent-roll in a town is annually costing many lost or damaged lives, especially among babies and young children.

Recently systems of education have been advocated in which the children spend much time in the open air, but as yet, from want of space, lamentably few children come under these methods, which are equally and advantageously applicable to nearly all. The few provided for in this way have generally been debilitated or diseased, but even with this unpromising material good general results have always been obtained.

Open-air Schools.—The open-air school originated at Charlottenburg in 1904, where, starting from the idea of the sanatorium for consumptives, there was planned the original "Forest School" for debilitated, anæmic, or tuberculously disposed children. Recently a secondary school on similar lines has been started where children who pay considerable fees, whilst becoming healthier, are able in twenty-five-minute lessons to keep up the same curriculum as the ordinary schools with forty-minute lessons.

Designed to further natural physical and mental development by the removal of all possible hindrances, the open-air school breaks away at once from the usual academic course of learning, which is a survival of the old Elizabethan grammar school with its false ideals of educational values, an academic rut from which we have not yet got free. *Pari passu* with separation from this rut is success assured.

The requisite conditions for healthy growth and development are (1) food in abundance, (2) cool moving air to disperse the heat and moisture from the skin, (3) free and intermittently violent exercise to stimulate function in various organs and promote lymph circulation, (4) rest, time for tissue repair, the organization of thought, and the avoidance of fatigue. These are the main needs of children in education; others are subsidiary, and any one of these failing, the child is deprived of natural requirements and, indeed, natural rights. In elementary schools most children fail in one or more of these needs, and in some of the poorer districts many children may fail in all.

The Charlottenburg model of school gives the children three good meals a day; three should always be required. Where a dinner is given to replace the midday meal owing to distance from home, it is often insufficient, especially with debilitated or possibly tuberculous children. Meals brought from home should never be allowed, as they are rarely suitable. It is common experience that some articles of diet are refused at first by children, but if persisted with, after two or three refusals to more than taste the ration, it is generally eaten.

The fresh cool moving air ventilates (see Ventilation), and in removing heat and moisture from the skin has also powerful tonic effects, and the due heat removal aids metabolism so that nutrition improves, and chronic sores and discharges sometimes of long standing tend to heal. Clothing warm enough to prevent actual chilling of the skin surface should be worn, and dry shod feet are necessary. Wooden pattens such as are used in the rainy Faroe Islands by the women would be very useful to step into and keep the feet dry; clogs have disadvantages. The children soon get used to the cool air, and are less liable to colds or infectious diseases than other children, but damp and cold are to be remembered as risky for rheumatism. Blankets, rugs, or sleeping-bags are usually provided. In Chicago the children have "Eskimo suits" for winter.

There is usually plenty of exercise in the coming and going and constant movement of open-air work. For games, running and jumping, "follow my leader" in bursts, and obstacle races are all of interest, and to be usefully employed. They will be much superior to any formal breathing exercises. Mouth-breathers should be taught to breathe with the mouth shut; in fact, the mouth should never form part of the respiratory tract except in speaking or singing. The avoidance of long sitting in class is an advantage. For the sake of mobility, chairs and trestle tables should be used instead of desks. Many schools are furnished with long forms without backs, which tire the children. Desk work should be almost eliminated. There should be no formal writing lessons, very little reading of books, nothing of mere memory work, and the large proportion of school work which is academic lumber should be dropped wherever possible. In the properly managed open-air school, along with the increased nutrition which accompanies good feeding, the stimulation of the fresh air, the feeling of freedom, and with the rest, and free lymph circulation, absence of tiredness and fatigue, there comes a strange sense of contentment, a *joie de vivre*, and a sense of fellowship in work. A goodwill and desire to do things and to learn, which is most impressive to those who watch the eagerness of the children, and the happiness reflected in their faces, are some manifestations of the open-air treatment. Children want to make and do; here they learn to fix, construct, level, and measure, and acquire a real knowledge of objects and values, instead of an acquaintance with words and diagrams; and more important still, whilst handling and doing there is sufficient time during the work to organize permanently ideas and concepts. This improvement in temper and spirit is often noted in playground classes, poor substitutes though they be for the open-air school. One can still recall how during schooldays the time was looked forward to when there would be no more school tasks and no more home lessons, but plenty of time to do and make things. The open-air school in the hands of capable teachers realizes this opportunity which the child desires. The success of the Boy Scout Movement depends on the same co-ordination of elementary spontaneous activities and ideas to definite ends. To the teacher, however, the work at first is strenuous and unremitting, and it demands originality and freshness, to such a degree that with extension of these schools a special type of teacher will arise, who must be given a free hand to conduct the work in his own way in detail, varying with weather and season, and to maintain its freshness and educational value, so long as general regard to fundamental principle is carried out.

These educational suggestions have been referred to here because they involve physiological principles for the growing child and recognize the elementary nature of its psychological actions, so frequently overrated by educators. It was Binet who pointed out that children were prescribed by regulation to be instructed in "Cameos from History" at an age when they did not normally distinguish forenoon from afternoon.

The bracing effect of the open air is much enhanced in most recent schools by the tonic results of a shower-bath two or three times weekly. The daily rest and sleep has been an accidental but most fortunate introduction; at Charlottenburg the children took the midday rest, which is so common on the Continent that even the banks close for a couple of hours; this rest was introduced with the schools to England and America and is now universally accepted. It is scarcely realized that not only the debilitated and the infant, but all rapidly growing children require at least an hour or more of rest, interpolated in the working day. The deck-chairs used for this at Charlottenburg were cramping and objectionable, and now are generally replaced by horizontal stretchers, on legs which fold flat for storage.

Where such a school for a hundred or more children is instituted, if the selection made is of unhealthy, ailing, debilitated, and ill-nourished children, frequent visits of the doctor will be necessary and a nurse should be in regular attendance. The nurse has to remember that she is not only a nurse but also a school nurse, who has to be as original and versatile as the teacher, and should make her ministrations thoroughly educative. She is teaching the way to healthy living, and should for this purpose be the chief intermediary between the homes and school. Each child needs its health card made out, and for a time after entrance the temperature should be recorded until this has been normal for four successive days. The weight should be noted at weekly intervals. In working up these records, the seasonal variation of weight increase —slow in spring, great in autumn—must be remembered. In debilitated, ill-nourished children dilatation of the heart may occur, when the child appears ill and fatigued without sufficient cause. Any rapidity of pulse, breathlessness, or disinclination to exercise should be watched in a child whose heart is suspect. Children with actual tuberculosis of the lungs or rheumatism rarely do well in these schools.

Open-air arrangements may be classified as:—

A. Open-air Schools.

i. The open-air school or forest school (as at Charlottenburg), where children attend daily, returning home at night.

ii. Open-air schools in towns, where children also sleep at night (as at Deptford).
iii. Residential country or seaside schools, schools of recovery, where children can be taken into a fresh environment for many months.
iv. Schools on floating hulks (as in New York).

B. Modifications of ordinary day-school arrangements.
i. Verandas, open-air classrooms, roof classes.
ii. Playground classes, classes in parks and open spaces.

C. Short periods of recreative variation in school arrangements.
i. School wanderings or excursions for one or more days or weeks.
ii. Vacation schools in the open.
iii. Country holiday schemes for one or more weeks.

These arrangements may be applied to groups of children selected according to health, ability, residence, age, or school, or, again, only the physically defective or only the tuberculous might be admitted. In the last cases, to attempt the inculcation of thrift by the fixing of any payment is a restriction militating against success, often cutting out some of the most suitable but needy cases.

Tuberculosis Schools.—In the so-called tuberculosis schools, if the children are markedly ill or feverish the institution becomes a sanatorium where medical care is more important than education, and although day schools exist for children affected by pulmonary tuberculosis, in the children's interest they should all be replaced by residential country schools. The child with pulmonary tuberculosis has almost certainly been infected by a phthisical adult, probably in its home, and recovery is more likely if removed from this environment. In order, however, to secure that the expenditure on this removal from an infected environment is not largely wasted, evidently action should be taken by sanatorium treatment of tubercular adults, for instance, to minimize the risk to the child on its return home. The tuberculous child, if its lungs are threatened, is in urgent and immediate need; it should not be kept waiting months whilst possibly hope of recovery is daily diminishing. Such a child is the victim of social circumstances for which the State is to blame. The day school in regard to phthisical children should be prophylactic. It is mere quibbling to say that Regulations do not admit of this. These day schools are only justifiable if they admit of the education, sanitary training, and medical observation of children coming from homes where consumption exists, but who themselves, although suspect, are as yet apparently free from the disease. All children in these schools should have their temperature noted twice daily; a chart for this purpose can be got extending on a card of 6 × 8 inches for the year, their appetite should be watched, exercise must be carefully regulated by the temperature, and much rest is also to be provided.

Open-air Schools with Sleeping in Towns.—The idea of an open-air school in a densely populated town area, where instead of going back to small, stuffy, overcrowded rooms at night the children can sleep in the open, has been successfully tried on a small scale at Deptford. If the children are allowed to go home for their midday meal they act, too, as health agents in their own homes.

Residential Schools of Recovery.—These schools are required for about 1 per cent. of the scholars on the rolls of elementary schools in towns. Although a few are in existence their importance and necessity have not yet been fully appreciated, but full recognition of the need of these schools cannot be long delayed. The need was set out in 1907 in the Report published by a Representative

London Committee on Medical Treatment of School Children, which divided ailing children into three classes, the first being "those requiring care in an institution, and an outdoor life; i.e.—

(*a*) Debilitated children;
(*b*) Children convalescent from tuberculosis treated surgically;
(*c*) Children suffering from subacute or early tubercular disease."

"A large number of the children of this class can only be effectively treated by segregation in institutions intermediate between the hospital and the special schools, situated in the country; but in order adequately to provide for these children, whose physical debilitation constitutes a grave national danger, a number of residential schools will be necessary."

Open-air Classrooms.—The usual idea is to make one side to open freely on a veranda. Whilst these rooms have a prophylactic aim, and are better than the ordinary room in having a much greater potential air space, they fall short in the other factors which contribute so materially to the success of the typical open-air school. Some recent rooms *opening freely with large studio windows, and with the old Roman method of heating through the surface of the floor, kept at 80 degrees, have been used in Derbyshire. The schools for Physically Defective should approximate to this type. A good example where the whole side of the classrooms is open to a veranda is seen at Duncan Street in Edinburgh.

Playground Classes.—These are usually held in the six summer months. For the relatively few children who attend they appear to do good in proportion to the time spent in the open air and the reduction in written work and academic grind. The open air is designed to be stimulating and also calls for increased heat production—this means more food. The playground classes make this extra demand without generally affording the necessary increase of feeding. They usually also fail to provide any rest time. Probably they will gain in educational value as knowledge of open-air methods spreads. Observers concur that, even if physical measurements should not show it, there is an improvement in nutrition indicated by the tendency of wounds and chronic sores or discharges to heal. The appearance of the children's faces too, "the open-air smile," and increased interest in their work are characteristic; the spontaneity, originality, and alert response which they show are more pronounced as these classes approximate to the typical open-air class by being held in parks or large open spaces. Whilst it is an advantage to have the school as a depôt, many of the teachers speak of work in the playground as a constant struggle with adversities. The chief want is protection from rain; shelters are often available, but they are small and complained of as dark, although generally the photometer shows them to be two or three times as bright as the light falling on the average school desk. Protection is needed from the prevalent wind, which in England is south-west and often rainy; at other times dust is much complained of, and the curiosity of passers-by may cause interruptions. The glare of sunshine on white paper can be mitigated by using tinted paper, which should be on blocks to avoid wind effects. It is an advantage to avoid book or paper work except for notes. Pencils are preferable to pens. Collapsible seats and trestle tables are required, as ordinary desk work is out of place. True free-arm drawing, which from dustiness and want of space is almost impracticable in rooms, although most desirable educationally, can be done on the prepared outer walls of the school building. These classes are disappointing for the poorer debilitated children, as they do not provide the safe social environment obtaining in a residential country school.

School Journeys.—These expeditions extend from an afternoon ramble in some park to journeys of hundreds of miles, lasting over many days. Their educative effect as new life experience is yet scantily appreciated by those without actual experience of it. The preparations, the co-ordination of various arrangements, the meeting of emergencies, are all of educational value. The children who go on the longer expeditions have to be selected as regards general fitness and cleanliness, and the possible spread of vermin has to be watched. It is unwise to take any child under ten years old. Debilitated or weakly ones must avoid long or strenuous work at first; they may actually suffer, and if at all flabby or ill-nourished are disposed to show dilatation of the heart.

The ideal selection for the strenuous sight-seeing holiday would be children selected for their capabilities and of about the same physiological age, the hard work of the journey being arranged for the last half of the time. Other children do better at the seaside, where the tonic effect of winds and intermittent exercise broken up by lazing makes itself felt. German observers have found that children doing excursions over flat land do not gain weight equally with those doing strenuous journeying in hilly districts. Short spells of exercise and short rests appear to be the best way of progress for children; a ten hours' rest at night is necessary, and while meals should not be large, frequent small drinks of water are allowable.

Blistered feet are to be expected; plenty of boracic acid powder will be useful. Accidents may cause wounds or even broken bones. Stomach troubles, constipation, or diarrhœa are common. Illnesses, however, like sore throats, quinsy, or even diphtheria, have occurred. If the best care is to be given to sufferers, it should be clearly understood that no liability for expense or loss will fall on those in charge.

Vacation Schools and Play Centres.—In the poorer parts of towns, or even of country places, the school seems to play a civilizing part, especially in respect of cleanliness and good behaviour. Too often, indeed, the child has a school way and speech quite apart from its mother-tongue and life in the family. "The school proposes, but the slum disposes." Some teachers note as a holiday effect a relapse into savagery and dirt. Less than half the children go away in the summer; the average number absent is about 20 per cent., and the average absence a fortnight of the holiday month.

To walk the reeking back streets of a squalid neighbourhood in a summer evening and see the poor little things amusing themselves writing on the pavement, chalking little sums, and crowded all over the asphalt, is a most piteous and disheartening sight. The need for twenty times the number of playgrounds, and ten times the present space, for children is one of the pressing wants of our English towns. "Chicago in recent years has set the whole world an example in its abundant provision of playgrounds and meeting-places for circles and clubs, children, youths, and old people, representatives of many nations and many shades of opinions, yet united to maintain the decorous conduct of their various societies practically without official help. All these halls, rooms, gymnasia, baths, and playgrounds are maintained by the city for its inhabitants and given to them free of charge."

Country Holidays are nearly always arranged on the objectionable charitable basis and to a considerable extent apart from school organizations or authorities. The schools can make them useful by arranging that no child shall be sent away unless clean and free from obvious risk of conveying infectious disease.

Reports on Open-air Work.—In making notes, each child should have a separate card record; for delicate children temperature and pulse should be recorded for a time; the weight should be recorded fortnightly, for others monthly. It is difficult to use controls, but for many scientific inquiries control children should be observed of corresponding age, sex, height, and weight, if possible, at the start. Owing to possible seasonal variation in growth, hæmoglobin, appetite, or clothing, the children can only be compared with others during the same periods and seasons of the year. The variations in the three months March to May differ perhaps from August to October, and neither is to be taken as three-twelfths of that for the whole year in normal children. As records for comparison of classes the frequently used average growths, the greatest or least gain, are quite futile.

Enough has been said to indicate that the whole future success of elementary education as a physiological process depends on approximating the child's life to that in the best type of open-air school. Abundant fresh cool air is needed, but the child does not live on air, so good food—as much as a child will take—is wanted; and in order to get full benefit from this, plenty of space for exercise, running, jumping, and games is required, with some restriction in purely literary work before the age of ten or eleven, and considerable shedding of the educational lumber that still chokes time-tables Lastly, and perhaps most important for the growing child, a minimum of one, better one and a half, hours of quiet rest or sleep should be interpolated in the working day. Many accessory provisions generally neglected, such as bathing, suggest themselves, but the above are the fundamental requirements which should become tests of good educational provision in the next decade.

CHAPTER V

TONSILS

Enlarged Tonsils and Adenoids.—Apart from dental troubles, the children who suffer from tonsils and adenoids form the bulk of cases that are noted as requiring treatment. No teachers should think themselves fit to have charge of an elementary school class who cannot form a shrewd opinion as to whether a child is suffering seriously in this respect and needs to be referred to the school doctor.

The normal tissues about the surfaces of the nasal and oral cavities are chiefly exposed to noxious foreign elements, of which perhaps the most dangerous are living organisms. Certain powers of digesting or destroying hurtful foreign elements, whether living or dead, possessed by nearly all the body cells, are described. In the more specialized structures these powers are in comparative abeyance, but are prominent in some leucocytes or white corpuscles, and especially in those found in lymphatic structures. The defensive powers of the lymphatic cells may be seriously lowered by poisons such as alcohol, or the chemical products of fatigue; they may also be raised by certain chemical vaccines now prepared, and should be vigorous and active in ordinary good health. The harmful elements are dealt with by the cells in lymphatic structures around the nasopharynx. In individuals of robust health the leucocytes have such powers that conditions of chronic inflammation are rarely evident, but in others of less vigorous constitution, or debilitated by depressing surroundings, or such causes as want of food or chronic fatigue, low inflammatory conditions soon show themselves.

The tonsils on each side of the fauces are the most easily seen of such lymphatic masses. All degrees of enlargement may be noticed. Mere mechanical obstruction of enlarged tonsils or adenoid masses may prevent correct articulation. This sometimes occurs even in pupil teachers. The enlargement may cause increased efforts resulting in mouth-breathing. There is no diminution of the oxygen reaching the lungs sufficient to cause anæmia or debility, although this is sometimes asserted, these affections being due to toxic causes.

The accumulation of decomposing secretions on the surface and in the crypts of the tonsils often leads to the production of offensive and poisonous bacterial material. The tonsil, too, appears as a weak spot for the entry into the tissues of various organisms, being regarded as a main portal for the entry of rheumatic, scarlatinal, diphtheritic, and other dangerous blood infections. The enlarged tonsils are usually indicators of further changes. The lymphatic masses about the upper part of the naso-pharynx, and the mucous tissues about the posterior ends of the turbinate bones, are liable to become greatly hypertrophied, and sometimes cause trouble through their chronic irritation. This is mainly due to mechanical substances in the air, or more commonly micro-organisms, want of proper drainage of the surfaces, or the want of development due to mouth-breathing established at an early age, which mere catarrh set up by the baby comforter may cause.

Results.—Catarrhal attacks result in infection of the tonsils and neighbouring lymphatic tissues, and in children of low vitality the infection sets up chronic inflammation in these structures. Thickening of the soft palate leads to impaired tone in the nasal sounds. Discharges sometimes start a pharyngitis, which gives the child an excoriated upper lip and the appearance of having nasal trouble. A remote result not uncommon is persistent conjunctival troubles and inflammation of the lid edges (*blepharitis*), which, if a cure is to be hoped for, requires treatment at a throat rather than at an eye hospital. The associated catarrhal conditions of throat and nose are a common cause of recurrent headaches in young children.

Aprosexia.—For some reason apart from the organs of the special senses, the existence of hypertrophied structures in the naso-pharyngeal region, adenoids especially, is occasionally associated with a peculiar mental condition termed *aprosexia*. The condition is very variable, and has been termed spurious mental defect. Temporarily, apperception is greatly lowered and the attention cannot be maintained. The functioning and probably nutrition of the frontal areas of the brain seem affected, whether by accumulation of fatigue products, from interference with lymphatic drainage, or in other ways is not clear. The condition is remarkable for variability. Quite sharp and intelligent at times, such children are as often dreamy, absent-minded, and wool-gathering. The variations depend on the condition of the throat and nose, and are more obvious when the structures there are swollen from catarrh, especially from humidity of the weather. These children are always mouth-breathers, and often have other sequelæ of the adenoids from which they suffer, not the least of which is said to be a character, in later life, timid, fearful, and doubting. The most immediate change, however, is a thickening of the tissues, starting in the structures about the Eustachian tubes, which lead to the middle ears, often causing secondary aural changes, and through the throat catarrh sometimes setting up very intractable deafness in early middle life. In slighter cases, with growth, recovery appears to take place, and the children may leave school apparently well, whilst the slow changes are leading to ultimate inefficiency from hardness of hearing. Over 5 per cent. of mothers attending medical inspections are noticed to present obvious deafness due to old adenoids or aural suppuration.

Otitis and Mouth-breathing.—Sometimes during childhood the grosser form of suppuration of the ears and discharge takes place. This is more likely to happen in those scarlatinal or measles cases who suffer from adenoids than in others. Out of 1,000 children in the East End of London 15 per cent. of mouth-breathers had ear discharge, but only 2·8 per cent. of the normal breathers. Mouth-breathers are more disposed to all the dangers of suppuration of the ears, meningitis, or blood-poisoning than other children, and many lives are cut short from neglect of this condition. Even in the inspection of children sitting in their places the majority of mouth-breathers are at once apparent, and it is also noticeable how educationally they gravitate to the junior classes. It is difficult to be sure whether by mere mechanical obstruction a vicious circle is set up, but every surgeon of experience knows how many a child with open mouth, frequent nasal discharge, and generally-unintelligent appearance, may be improved wonderfully by operation for removal of obstruction. In bad weather and times of prevalence of diphtheria or scarlet fever it would, however, be generally wise to postpone any operations.

Breathing and Handkerchief Drill.—The breathing and handkerchief drill of the infant school should require the child to breathe in and out with the mouth shut, and this would have additional good effect by directing attention to defects. Any teacher who notices mouth-breathing must warn the parents early; if, in addition, the child snores habitually at night, it may be confidently asserted that such a child requires operation to clear the naso-pharynx. About a third of the children in school show some hypertrophy of tonsils or adenoids, but nothing like this number require surgical treatment. Up to 10 per cent. of children on admission will be marked mouth-breathers, and during school ages the condition remains comparatively steady. Probably some 3 or 4, certainly not more than 5 per cent. of school children require operation, although school doctors often return numbers in excess of this. Mouth-breathing persists in many cases after operation unless the child is taught to breathe correctly. In the mentally defective about 50 per cent. are mouth-breathers, the habit having been set up by some infantile catarrh and allowed to persist from neglect. It is only in the slightest cases of mouth-breathing that any benefit is got by exercises alone; and in such cases there is a considerable tendency to recovery without the exercises. Advice so often reported as having been given by the family doctor, that the child "would grow out of it," has probably an equal element of truth to the supposed benefit from breathing exercises, always provided that the child escapes the risks of serious danger, or later of becoming the victim of gradually progressive hardness of hearing.

Quite good results are got from operation in careful hands, but the majority of elementary school children noted after operation are in an unsatisfactory condition, chiefly from neglected turbinal hypertrophy. The greatest proportion of unsatisfactory cases are among those operated on at large general hospitals. The parents require a good deal of instruction as to the hygiene of the child both before and after operation, and the school nurse can best impart this.

The Public Health Problem.—The existence of enlarged tonsils and adenoids as a public health problem is in no way satisfactorily treated by selecting as many as a third of the children in whom these structures are pathologically changed for even the most successful operations. When a third of the children in the schools present conditions which indicate severe struggle against the factors of ill health, the causes must be sought out and remedied. They are causes also at the roots of tuberculosis and other states of chronic debility.

The external factors are the various kinds of septic organisms which gain access to the nose and mouth. Each human being goes through a period of acquiring a proportion of immunity against various diseases. Provided the dose of germs is small enough, almost any disease is overcome, or rather its germs are overcome without the disease becoming evident. Tuberculosis thus affects 95 per cent. of the population ere schooldays are past, but unless the doses of infection are many or large, or the child is unbalanced by the results of other diseases, as measles or whooping-cough, it soon overcomes the attacking tubercle germs. One purpose of public health is to diminish the dosage and frequency of infection by tubercle bacilli while increasing the individual's resistance. There are a number of germs of comparatively low pathogenic powers against which only temporary immunity seems to be conferred by attack. The common "dirt" infections of the eyes and ears, and fungus rashes of the skin, so evident among debilitated children and invalids, afford examples. Where-ever there is malnutrition they tend to assert themselves. Catarrhal attacks, the common colds, the micro-organisms of which cause an enormous diminution in health and vitality annually, these too can be resisted easily in health, but the germs are so omnipresent that, especially in conditions of debility, any slight departure from a condition of resistance, a few minutes' chilling, a slight attack of indigestion, will give the opportunity for invasion.

In the case of young children improper clothing, bad feeding, or the use of the dumb teat or comforter, may contribute to the catarrhal attacks which ultimately lead to the enlarged lymphatic tissues just considered. The factors contributed by the child itself depend to some extent on its bodily constitution. The children of a family who in other respects resemble a mouth-breathing parent are likely to be mouth-breathers, whilst the rest are like the other parent and normal. Lack of resistance in the cellular elements is sometimes induced or cultivated, as can be seen in the large, soft, well-clothed, scarcely exercised workhouse or institution children, so apt to develop chilblains or to suffer from adenoids. So, too, similar cultivated conditions in children are referred to on p. 185.

Preventive medicine requires the diminution of catarrhal attacks by raising the child's reserve powers. The chief early causes of catarrh are the baby comforter, maternal ignorance, and dirt. Room to live on the land is the principal need; house-room and all that it connotes, school-room, free spaces of land for air and play, chance of cleanliness and the tonic influence of school baths, are all of great value.

CHAPTER VI

EXCESSIVE MENTAL EXERCISE AND FATIGUE

Fatigue is chiefly subjective. Rarely people are found who can work tirelessly till suddenly they collapse exhausted; others are born tired, "Weary Willies" who are always fatigued.

The subjective feeling of fatigue is a natural warning that physiological action is being overstepped, that reserves are being called upon, and that there is a possibility of danger. Only in great emergencies should such reserves be required, and then, as a rule, fatigue is scarcely noticed.

Experience shows that the developing nerve cell fatigues more readily the more immature it is. Irritable cells of structures like nerve or muscle may be pictured as producing their work by chemical change taking place in certain material of an explosive nature, which is rather to be regarded as a secretion in the cell than as a part of the more vital structure. The immature cell put into action soon runs through its small store of ready prepared explosive, and then functioning has to take place at the expense of the more vital structure, and so change is produced in the growing cell.

These immature cells are also easily affected by poisons and suffer excessively from the toxic effects of their own activity, among which are the fatigue-producing agents. Healthy nerve functioning is therefore largely a matter of good blood circulation and free lymph removal from the tissues, one being equally important with the other. This will be reverted to in discussing physical exercise.

In the young child whose tendencies are to muscular activities, the motor neurones are in the stage requiring much functional exercise; if this is not provided, blood circulation and lymph removal are affected, and these secondarily react on the development of other immature and still later developing and higher functioned cells. Thus, too much sedentary life in the classroom may possibly be a sufficient cause for apparent overpressure without much mental exercise. Another cause, to be discussed in connection with ventilation, is the result of heat accumulation due to excessively warmed air in school-rooms, and this probably is temporarily more generally effective than any mental work. The effects of long-continued work can be summed as (1) gradual exhaustion of the energy-producing materials in the nerve or muscle cells, requiring fresh nutritive supplies and rest to make good; and (2) the poisoning effect of the waste products (fatigue toxins) which produce the subjective tiredness, and to which some individuals are more sensitive than others. These toxins are best got rid of locally by good blood and lymph circulation, and generally by healthy glandular action, destroying or excreting them.

A young child developed with due regard to its physiological order of evolution, with active blood and lymph circulation, can scarcely have mental strain. Attention is always the highest function of the nervous system, and with the onset of fatigue the child simply ceases to attend. The younger the child the quicker and more blatant its inattention.

Overpressure, then, is not usually the reaction of the nervous system to overwork, but rather the reaction of other insufficiently worked systems (circulatory, respiratory, lymphatic, digestive) in failing to provide for the nervous system to which they are the servants and adjuncts. The chief, and perhaps the commonest in the elementary school, is nutritional failure from insufficiency of proper food. Proteid starvation especially may merely show as mental inefficiency.

Education is the impressing of certain changes on the nervous system, a variation in nerve-cell structures, and the developing of new paths in the mechanism; it is only the still immature plastic cells which are capable of taking this impress of change. These are the cells which also fatigue easily; for this reason all educational effort producing changes in the cells involves fatigue. There is, indeed, no education without fatigue, but this should be healthy, and it is only fatigue not easily recovered that is bad.

Slight degrees of fatigue result in a preliminary excitement.

When the first nervous adjustments have been made and the toxic products resulting commence to stimulate the heart and quicken the respiration a little, a flush may come on the cheek, the lips are parted, the eye may glisten and the pupil widen. This is the picture of health—the reaction, for instance, to a bracing walk across a breezy moor. With this slight degree of fatigue there is increased ability to do what is wanted, and a little practice produces its "warming-up" effect, so that for some time there is increased quantity in the output, although the quality may gradually deteriorate. This goes on for an hour or more; then follows a slackening, and again an increase, till after three or four hours a steady deterioration of amount and quality comes on and exhaustion takes place, when the work can no longer be continued. If with sleep and rest complete recovery soon takes place, ere the work is recommenced, all is well. If the original starting-point is not regained in recovery before fatiguing work is recommenced, and if this happens day by day, then there is chronic fatigue or overpressure. Overpressure, however slight in degree, is chronic persisting fatigue, and it is dependent on the circulatory and nutritional mechanisms either being too weak or not having enough time and opportunity to remove the fatigue products regularly formed in work.

In relation to fatigue there are enormous individual differences, which are the expression of inborn structure and are tested by school tasks. They fall roughly into the following classes:—

1. The commonest type shows some fatigue in the first hour, with recovery, then fatigue again, and again recovery, till in the fourth or fifth hour exhaustion gradually comes on.

2. These are the children in whom fatigue comes on slowly, work reaching a maximum in about three hours and then tending to decrease in activity. They are generally attentive and industrious children without particular ability—the plodders.

3. Children who do not show marked fatigue. The curve of work runs evenly along, the child seeming to learn almost without effort.

Although heredity has the preponderating influence in all nervous actions, early school habits may have a good deal to do with the way of tackling schoolwork. Some make a maximum effort from the start, some waste time and take a great deal of starting. Possibly educational methods are sometimes at fault. Any method which asks for accurate and exact work from children under ten years of age is thoroughly bad. It is educating for mediocrity in later life. As Boole also expresses it in heavy Victorian style: "A premature converse with abstraction is fatal to a virile growth of the intellect." This is an old cry from the days of Rabelais and Montaigne, that some faculties were in danger of annihilation rather than of development through school influences. The real educational method from the point of view of nervous development is to set out the task clearly by word or object, and let the child do it as it likes, but as quickly as possible, trusting the nervous system to make its own adjustments in due season. All other slow and exact methods for children are wasteful and exhausting, involving many fine adjustments by immature cells, which suffer from premature functioning or rather overfunctioning, and tend quite soon to boredom and fatigue.

Attempts have been made to ascertain by some comparative tests a coefficient of fatigue for different studies, but it is very doubtful what value can be assigned to the various numbers given. So much depends on the actual age and the earlier training of the child. The pupil may have considerable artistic instincts, but routine studies of freehand drawing, done an eighth of an inch at a time with much use of indiarubber, not only help to destroy power of artistic expression in the future, but make the actual lesson one of the most tedious and fatiguing in school-days. Again, it is only rare and precociously developed brains that survive unhurt the painstaking and accurate drilling of a classical training before puberty, which makes literature in later life an aversion to so many, and his classical room a horror to the normal boy. For this reason no attempt will be made here to analyse the causes of fatigue in ordinary school lessons; experience must still estimate their value, although special points will be dealt with under other heads.

Tests for Fatigue.—The numerous methods of estimating fatigue are neither easy nor exact. Much refinement, but little practical advance, has been made in recent years.

The various methods can be grouped as—

I. Psychological Methods—the most interesting to schoolworkers. The diminution of mental powers can be tested by the amount of work done and the mistakes made in a given time. Examples of these methods are—

(i.) Counting the letters in a printed passage during a certain period. The number of letters counted diminishes with fatigue. This is a rough test.

(ii.) Sikorsky, the earliest worker in this subject, used dictation tests. He had a dozen propositions, each of twenty-five letters. Once a day at different hours the children were tested, and the number of mistakes from inattention were noted and taken as an indication of fatigue, so that the whole picture was gradually built up.

(iii.) Burgerstein, whose paper on the "Working Curve of an Hour" became classical, used a large number of small sums in addition and multiplication, to be worked for ten minutes with five-minute rests. Then from the quantity of work done and mistakes made he obtained the working capacity as a measure of mental fatigue. From practice the amount of work increased rapidly, but the number of mistakes and the corrections made increased in a much greater ratio.

Attempts have been made in great variety to estimate either single activities, such as crossing out letters, interpolating missing letters or words, reckoning methods, or methods combining various activities. It is obvious that all these estimate the output and quality of work and not exactly the fatigue. Many of the results got by the various methods are not concordant.

II. Physiological Methods.—*Ergographic methods* measure, and in Mosso's instrument record, the contractions of the muscles of the forefinger when pulling against a weight till exhausted. The readiness with which the exhaustion of the finger takes place is held to be a measure of the general fatigue. The method has many difficulties in practice.

Other methods of a muscular nature are tapping tests, where tapping on a recording key at the fastest rate possible is used to measure fatigue.

The combined hand and foot method has lately been suggested by Weichardt as a good test of general fatigue. Each knee is raised alternately once a second, till the thigh is horizontal; at the same time the "arm parting" movement is done to and fro, from the fingers touching in front to full extension of arms and hands in the same straight line. These movements can be done easily for a short time, then sudden exhaustion comes. The number of movements done to time gives an inverse measure of fatigue. Investigators have chiefly used this for personal daily records.

Æsthesiometric Methods.—Associated chiefly with the name of Griesbach, who developed the method of measuring the threshold of sensibility, the smallest distance at which two points could be separately recognized. This distance increases with fatigue. It also varies with temperature, humidity, and other circumstances, and is so delicate that it requires the touch of an artist to apply. It has been much used, particularly by Abelson, in recent years.

Optical Methods.—These are of extreme delicacy. An object viewed through two small holes in front of one eye is seen singly so long as the lens can be accommodated. If brought nearer than this it appears doubled. Measuring distances for near and far points of clear vision, the range for single vision decreases with fatigue.

III. Biological Methods—introduced by Weichardt—depend on the reaction to an antitoxin which he postulates as being produced by fatigue toxins, and which can be prepared artificially. Even if this is confirmed it will, however, fail to account for other than the subjective part of fatigue due to toxins. The dangerous part from exhaustion of cell materials apparently would not show in this method.

An example of fatigue tests in relation to atmospheric condition was to allow the work to take its usual course except that a set of twenty multiplication sums of three figures each was given to be done in five minutes. The work was given out at the beginning of the school session (Test I) and collected in five minutes. A like process (Test II) was repeated two and three-quarter hours later. The results of the tests were set out diagrammatically, marking

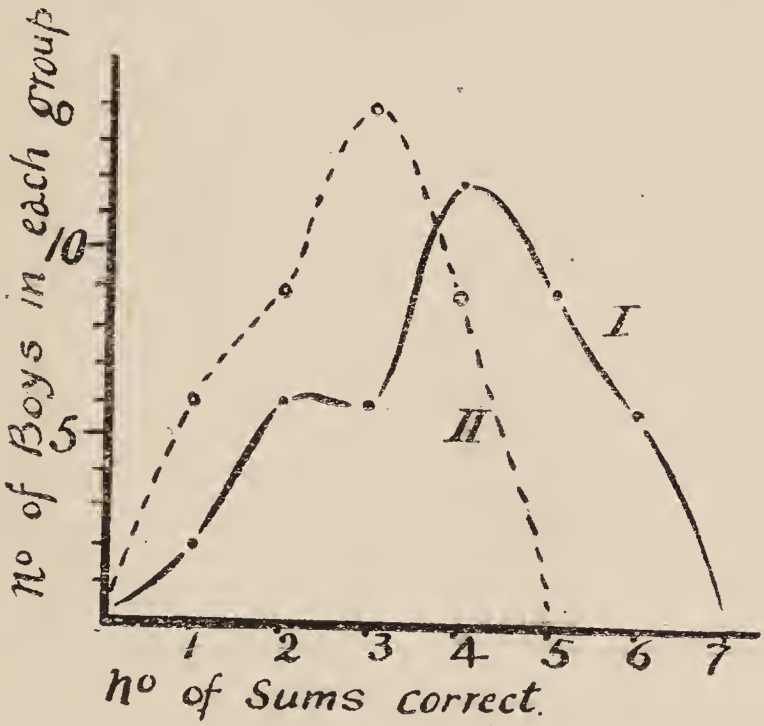


FIG. 9.—Record of fatigue tests.

Number of boys in each group, with number of sums done correctly. This is greater in Test I., the deterioration in Test II. being shown by displacement of the curve to the left.

off horizontally numbers to represent the number of sums done rightly by different groups of boys, and then marking vertically the number of boys in each group; on superposing the curves thus got, displacement to the right or left indicated improvement or deterioration in the mental capacity, which in the case illustrated (Fig. 9) shows deterioration. To express this in figures the average for each boy was taken.

Another way used to record the work was always to give the same amount of multiplications by three integers and represent this multiplied by the number of boys as a rectangle, whose surface was equal to this number of squares (Fig. 10). Then the number of right, wrong, and omitted sums, charted as plain, lined, and dotted squares in the diagrams given, and gain or deterioration in percentage right, wrong, or omitted can be numerically stated—in this instance being, for Test I, right 85·7, wrong 10·2, and omitted 4·0 per cent.; and in Test II, right 76·1, wrong

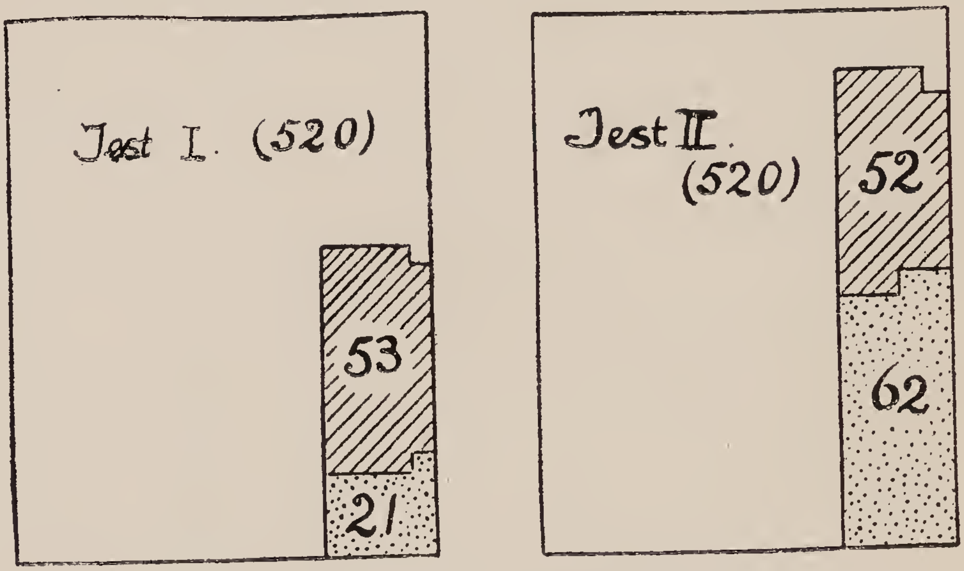


Fig. 10.—Record of fatigue tests.

The sums worked in the two tests represented by areas. Right, plain; wrong, lined; omitted, dotted.

10·0, and omitted 13·5 per cent. Control classes should also be used, where the conditions to be tested can remain normal whilst in the experimental class they are varied.

Attempts made by such methods to get exact knowledge of schoolwork cannot be said to be more than suggestive. Severe mental fatigue, as measured by the ergograph, comes on with great regularity in the sessions of mathematics and gymnastics; while, on the other hand, recuperation seems to take place during the sessions for history, geography, and nature study. Modern languages occupy with respect to fatiguing power a middle place. Singing and drawing, moreover, make rather greater demands on those who do well in these branches.

Nerve Signs.—School observations by Warner in the early nineties almost popularized the school hygiene movement then just beginning. He described certain nervous signs.

The position of the hand gives useful indications. In children, when the hands are held out in front of them at the word of command, they are pronated (i.e. the back

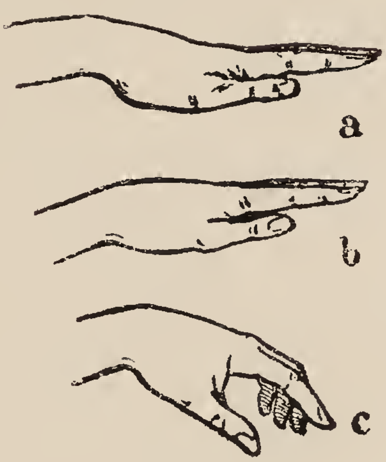


FIG. 11.
(*a*) Hand-balance tense.
(*b*) ,, normal.
(*c*) ,, relaxed.

of the hand is uppermost), and both arms are stretched horizontally on a level with the shoulders; in normal children the hands are flat, but in nervous and excitable but weak children the position shown in Fig. 11 (*a*) may be taken, the wrist being slightly dropped and the fingers bent upwards; in exhausted children the whole hand and wrist may drop, as in Fig. 11 (*c*). The thumb only may drop or all the fingers.

Balance of the Head.—The head is held erect without effort if the child is fresh, but when tired the head leans forward or to one side.

Combined Tests.—Dr. Warner has attacked the same subject from a wider standpoint. He divides his study of children into a study of neural and mental defects. The face is in its muscles a most accurate index of brain actions. Notable facial signs are—

Frontal muscles overacting, causing horizontal creases in the forehead.

Corrugation or knitting of the eyebrows. This sign when alone is often associated with a "status of mental stress which may be discovered on further inquiry." It is also a frequent sign of hypermetropia, or longsightedness, causing eye strain.

Orbicularis oculi relaxed (i.e. the muscle around the eye). This causes the lower lid to appear baggy and relaxed.

Mouth open. This may be due to chronic naso-pharyngeal obstruction or be merely due to muscular relaxation.

These signs of neural defect are those most likely to be useful. A *facial expression* indicating exhaustion cannot be easily described, but should be observed by the school-worker.

The great test of fatigue as observed by the teacher or public speaker is the degree of concentration of attention. A good teacher holds the attention. With the onset of fatigue, in which at first probably the toxic element is most prominent, the subjective feelings only come to the front as attention fails. In the case of the child it may not be feelings of tiredness about the head or neck, but it may be undue irritability; the attention, instead of being concentrated on work, wanders to feelings of discomfort or pressure from the seat or desk, and a shuffling of feet or bodies begins; irritation of the fauces by some scrap of mucus makes cough insistent; a fly crawls on the wall, a spot of sunshine flickers, and so the attention is lost. This, however, only represents fatigue as it appears in a temporary way, and the younger the child the sooner this will appear. Chronic fatigue or overpressure is the more serious kind, and in the elementary school is rare as a result of school-work, although not uncommon as a result of out-of-school work. As seen in young children—little Jewish boys, for instance, who study the Scriptures at early ages and at all hours—the picture is that of extreme delicacy and ill nutrition, with a limp and drowsy attitude, which becomes momentarily alert and brisk when questioned. The child gives an impression as if its growth had stopped, as possibly it has. In other cases of young children they seem to want nutrition and rest. Many such children are or get quite dull, and appear to have their mental development retarded for a year or two, only passing out of the suspicion of amentia about the ages of ten to eleven. Large towns furnish many instances of this spurious mental defect or false amentia among children, who brighten up considerably with a relative lightening of their load, by better feeding, more rest, as in open-air schools, or less classroom work, as in the playground classes. In the secondary school, or even in the older pupils of the elementary school, overpressure is commoner. Here again it is largely a matter of poor physique. Girls especially show overpressure also in yielding muscles, and are more prone to suffer than boys. Chronic overpressure may first show by its effects on the higher brain centres, and the child's social relations become disturbed. It becomes wayward, and from want of higher control is likely to be unduly emotional or reserved; inattention, loss of memory, and neglectfulness may appear; the child may be guilty of petty theft, or trivial and often meaningless lying. These symptoms, too, are common when the psychical pressure of puberty is being felt, and in the year or two after, when with defective mental and physical hygiene, hysterical emotional conditions may be pronounced. To dismiss a child from a secondary school for such occurrences without a thorough psychical inquiry into all the possible sources of its delinquencies is only excusable by ignorance in the teacher.

The indirect effects of noise, bustle, and considerable railway journeys on pupils are sometimes very evident, and should be minimized for both scholars and teachers.

CHAPTER VII

THE CARE OF ABNORMAL CHILDREN

The Mentally Defective.—Many children in consequence of physical or mental defects drift behind their fellows within the scope of ordinary schoolwork. Many tubercular children who have been bedridden are backward, and seem defective simply from want of the education of natural experience, quite apart from schooling. More frequently in the poorer parts of cities others are retarded from malnutrition of the brain, and should be reckoned as spuriously defective, like the children who suffer through imperfect lymphatic drainage of brain areas arising from obstructed naso-pharynx. It is difficult to say where the boundary is to be fixed; education is chiefly directed to the development of mental qualities, to making potentialities into powers. These potentialities exist in the nervous system, which, like all bodily organs, is subject to great physiological variation, so that from the effects of heredity a person may be bodily sound and yet a long way below the average mentally, whilst many are also degenerated as the result of disease. Those persons are feeble-minded who fail to reach a certain general level of mental qualities; these are, however, not a class apart, any more than are the highly gifted. There is, indeed, a continuous gradation from the one to the other end of the scale. In a mass of individuals otherwise comparable, as, for instance, all the children of a town in their tenth year of age, if it was possible to make a numerical value of their intelligence, as can now be roughly done by tests to be described, the variation in intelligence would become evident. Marking off to the right from zero on a horizontal line distances proportionate to the marks assigned to the various grades of intelligence, and from each of these marking off on a vertical line upwards the number of children of each grade, through these points drawing a curve, this would represent

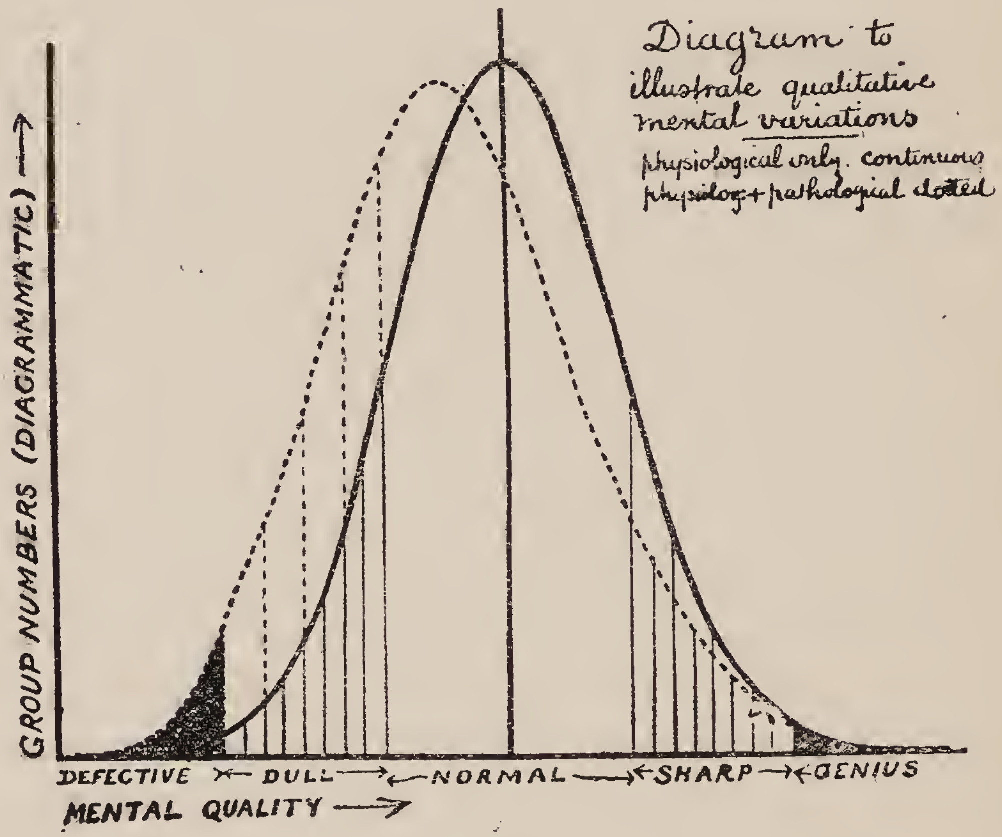


FIG. 12.

diagrammatically the physiological variation of the numbers and qualities of the various children's intellects measured by the scale. Marking off by a vertical line an area from the zero equal to 1 per cent. of the whole area between the curve and the base, this area would represent the numbers at the lower end of the scale of intelligence, who are commonly described as feeble-minded, although 2 per cent. would be really nearer the truth. If another vertical be drawn to cut off an area equal to 10 per cent., this area would represent the children who stick below Standard II or III in school-life, the dull and backward intermediate class who do not receive the benefit for after-life which they would if educated with special regard to the elementary qualities of their intellects; educationally they ask for bread, and, so far as they are concerned, are given stones. At the other end of the scale a similar area would represent the scholarship class, with the smaller area of brilliant children. The mass of intellect seems to thin out at this higher end. Remembering that disease tends to harm, and in the nervous system to degeneration of function, this curve of physiological variation does not fully represent the existing facts. The pathological effects of disease must be added to these of heredity, skewing the curve down towards the dotted position which more nearly represents the facts. It is, however, not necessary to know the exact amount, which must be determined by observation, to get a clear working representation of the subject. Here there is between the normally intellectual area, about the middle, and the mentally defective area below, the intermediate group touching them both, the dull and backward.

Backward Children.—In the first card inquiry on the physical, mental, and social conditions of school-children made in this country, about 1896, the classification of intelligence made by the teachers was influenced by so many other factors than the child's mentality that the standard in which the child worked had to be taken as a measure; even then a child of eight in Standard III assessed as dull by the teacher, and a child of eleven also in Standard III placed as bright, came out on the same level. Later experience shows the personal equation of teachers to be very great in this matter, and the assessment on shorter knowledge of mental condition asked from the school medical routine inspection is evidently so valueless that it is not worth recording otherwise than by a tick of the pen. As to educability, experience with children of different ages and different mental levels gives a simple judgment, difficult to analyse, but in practice so correct, that it is nearly always possible after seeing the child and noting its age, by asking such questions as, What is your name? Where do you live? How many fingers have you? What is a cat? What day is it to-day? What is the day after to-morrow? to state whether a case should be passed into a special school or not. Subsequent history shows that in most cases for practical discrimination anything further is almost waste of time. For a few doubtful cases it does not really matter where they go, and probably probation in the special school is the best chance for them. The forms now required in England are so needlessly detailed that they practically destroy much of the interest on the part of the medical examiner, and are yet themselves of scanty value in the returns made. Indeed, the careful filling up of the form almost precludes a good estimate of the child.

Adaptation Test.—The mentally defective child may be able to perform an action quite well, but some little change in the surroundings prevents him adapting himself, and Goddard has devised what he calls an adaptation test. A half-inch board about eight by eleven inches has four holes bored through it, the centres being $\frac{3}{4}$ inch from the end and $\frac{1}{2}$ inch from the sides. Three of these holes are $2\frac{1}{2}$ inches across; one is $2\frac{5}{8}$ inches. A circular plug about an inch thick and $2\frac{9}{16}$ inches across is just too large for the three smaller but easily fits the larger hole. The board is painted to appear similar on both sides. The child sitting on the left of the examiner, and the board lying before them with the largest hole at the top left-hand corner, the child is told that this stopper fits one hole but not the others; he is told to put it in. He may not succeed, or only succeeds after several trials. It is removed, and he is told to do it again, until he readily puts it at once in the top left-hand largest hole. He is told now to watch what is done, and the stopper being removed, the board is slowly turned over, taking two or three seconds to do this. The largest hole is now at the top right-hand corner. An intelligent child at once puts the stopper there, but a defective one again tries the top left hole. After this the board is placed in its original position, and the stopper being removed, the child is again asked to watch what is done; the board is then slowly turned over so that the far edge now becomes the near one and the largest hole is left bottom corner. The child again is asked to put in the plug. He may try the top left, or top right, or the correct one. This test brings out the adaptability of the child, and about 60 per cent. four-year-olds completely fail, whilst practically all normal eight-year-olds succeed. It is a test for the mental adaptability equal to that of a normal child eight years old.

Although this test was later devised than those which follow, it is given to explain the *rationale* of mental tests.

Mental Tests.—A finer assessment of the intelligence is sometimes useful for more detailed inquiries or with cases of merely backward children, and methods have been worked out by experimental observation on the lines of the above questions, and some simple actions, by Binet and Simon, in French schools. They formulated a series of tests corresponding to the intellectual level of each year of age, such as that for normal children. While only a few will do particular tests at a certain age, the majority will succeed at a year older, and all if taken two years older. For instance, a child at three years old should repeat a sentence of six syllables, at five years ten syllables, at fifteen up to twenty-six syllables; again, at three he should repeat two figures, three figures at four, five figures at eight, seven figures at fifteen. A child of six will state what a common object is used for, but at nine will give a much superior definition. Shown a picture, he names objects in it at three, describes it at seven, and by fifteen interprets it. By such means a scale of intelligence has been built up, and by comparing the intellectual age by this scale with the calendar age retardation can be stated. At nine years old, three years' retardation indicates mental defect. Although this is the best measure yet devised, it is by no means infallible and is only a very rough way of stating the comparison; for the ages above ten it is very doubtful whether its results are even comparable.

It is extremely difficult to say what is tested and how far ages are comparable on the scale. The tests, somewhat as modified by Goddard for American children, are given in Chapter VIII.

Classing children merely by their distribution in the school, from 10 to 15 per cent. are found to be so backward that they do not fully benefit by the schooling offered them. An analysis of a group of ten-year-old children showed that by this age opportunity, chance, or ability had distributed them over the schools as follows:—

Ten-year-olds.	St. I.	II.	III.	IV.	V.	VI.	VII.	Totals.
Girls ...	39	93	390	428	221	18	—	1,189
Boys ...	41	111	317	432	207	33	5	1,146
Total ...	80	204	707	860	428	51	5	2,335

Of these 2,335 children representing average samples, no less than 284 have got two to three years behind educationally; that is, 12 per cent. of the whole are

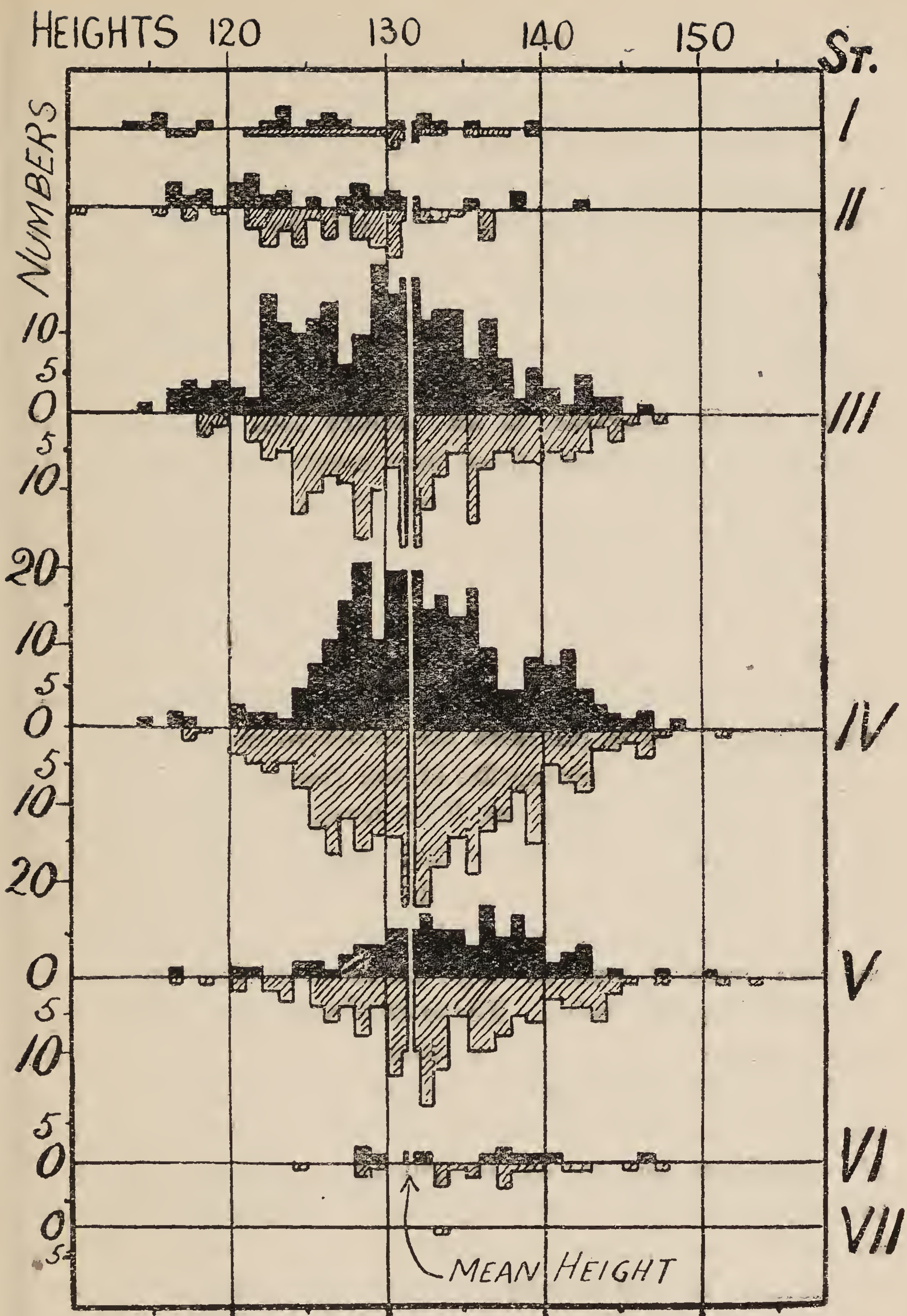


FIG. 13.—Distribution of 1,350 children aged ten last birthday, showing heights in centimetres and standards.

Girls (black) above, boys (lined) below, the base line of each standard.

evidently not profiting as they should from the education offered. About 1,400 of these were further noted as regards height (see p. 50), and Fig. 13 shows their distribution in the schools. It will be noted that the taller children are chiefly in the upper standards. This is partly an expression of heredity, and partly an expression of better social conditions in promoting a certain comparative precocity, physical and mental.

Dr. A. H. Hogarth, in an inquiry into the causes of backwardness, analysed these into mental, physical, social, moral, non-attendance, and combinations of these. Dullness short of what is actually classed as mentally defective preponderated, and this he again separated according as the children were intelligent but late developing children or dull children. He concluded that for a poor city district about 65 per cent. of children derive satisfactory benefit from schooling; about 21 per cent. fail to derive much benefit, as they leave before attaining the higher standards; and 14 per cent., being dull, derive but little benefit from the system of instruction in the elementary school. It is probable that a large number of these children are the exceptional children, or social misfits, which are now in America being selected, studied, and in large measure socially cured by the psychological clinics. These children puzzle and worry their teachers, are often a cause of anxiety to their mothers, and sometimes a distress to themselves. They are not merely wild or neglected, but suffer from all sorts of obsessions, phantasies, imaginings, emotions, and limitations, and no educational system is complete which fails to provide a means of studying and analysing their characteristics individually. Such observational centres have been suggested years ago, as they would repay more richly than any other educational means in proportion to the number of scholars handled, and every town should have access to a psychological clinic for its children.

The Mentally Sub-normal.—For the purposes of social life Sec. 1 of the Mental Deficiency Act, 1913, defines the various classes of mentally sub-normal persons according to conduct as—

(*a*) Idiots; that is to say, persons so deeply defective in mind from birth or from an early age as to be unable to guard themselves against common physical dangers.

(*b*) Imbeciles; that is to say, persons in whose case there exists from birth or from an early age mental defectiveness not amounting to idiocy, yet so pronounced that they are incapable of managing themselves or their affairs, or, in the case of children, of being taught to do so.

(*c*) Feeble-minded persons; that is to say, persons in whose case there exists from birth or from an early age mental defectiveness not amounting to imbecility, yet so pronounced that they require care, supervision, and control for their own protection, or for the protection of others, or, in the case of children, that they by reason of such defectiveness appear to be permanently incapable of receiving proper benefit from the instruction in ordinary schools.

(*d*) Moral imbeciles; that is to say, persons who from an early age display some permanent mental defect coupled with strong vicious or criminal propensities on which punishment has had little or no deterrent effect.

These definitions give some idea of the class of cases to be considered. Binet and Simon state as shorter definitions: "An idiot is any child who never learns to communicate by speech owing to defective intelligence, an imbecile fails to communicate by reading or writing and cannot learn to do so, whereas a feeble-minded person can communicate by speech and reading, but is at least three years behind the normal."

American writers do not restrict feeble-mindedness in accord with the British definitions, but extend the term to all mentally inferior persons, including imbeciles, idiots, and lunatics. For the congenital class of feeble-minded as defined in England the elegant term *moron* has been devised by Goddard, and it is often very convenient, expressive, and sometimes consoling to use. Putting idiots and imbeciles to one side, the feeble-minded come into consideration for education. This is provided for under the Elementary Education (Defective and Epileptic) Act, 1899, for those who "not being imbecile and not merely dull and backward are by reason of mental defect incapable of receiving proper benefit from the instruction in the ordinary public elementary school." This is a most excellent definition for the purpose of educational selection. The feeble-minded usually appear to lack the power of judgment, of constructing complex ideas, or abstractions from them. In rare cases extraordinary powers may exist in one direction with great defects in others, e.g. the so-called *idiots savants*, including reckoners, linguists, carvers, artists, and musicians. Markedly unequal development suggests degeneracy, and the lopsidedness, morally or otherwise, of many gifted persons is notorious.

Causes of Feeble-mindedness.—This may be due to want of proper evolution of the nervous machinery. A considerable number give a positive reaction to the Wasserman test, thereby suggesting syphilis as the origin of the defect. Cases where feeble-mindedness exists without obvious cause, and the individual has never been better than he is, constitute the so-called *primary amentia*, one of the terms which hide ignorance and should never be used if it can be avoided. Such amentia is no peculiar entity; it may be regarded as generally an extreme degree of physiological variation. Heredity is traceable in nearly three-quarters of the cases. With feeble-mindedness are found certain conditions, whether associates or causes cannot be settled. In an inquiry into the mentally defective and normal children in the schools of a district, tuberculosis and syphilis were found excessively among the feeble-minded families. Abject poverty is ten times as common among the families with feeble-minded children as among the normal families. The size of normal families averaged five, those with mental defectives averaged seven, whilst the causes of death among the young children were very different in amounts in the two groups.

Pathological causes may be classed as—

(i.) Old injuries about birth, hæmorrhages, or localized meningitis or brain inflammation result in cases which present paralyses from cerebral causes. Some of the cases free from palsy still have a history of meningitis which may have left deafness, or speechlessness, without palsy but with feeble-mindedness.

(ii.) Hydrocephalus is due to some meningitis at an early stage; children may be born with hydrocephalic heads. It is not necessarily a cause of defect. Helmholtz and Sir Isaac Newton were both said to have been hydrocephalic, but the extreme cases, although often pert in manner and speech, the funny boys of asylums, are usually very defective mentally in other directions.

(iii.) There is a small, undeveloped variety of brain termed microcephalic.

(iv.) There is a large, square-headed macrocephalus which should not be confused with the appearance of the rickety skull.

Two special varieties of subinvolution, quite distinct and characteristic, are known, namely, Mongolism and cretinism.

Mongolism occurs usually in a child generally without defective, or rather with a good family history, often the last of the family, most commonly with a mother aged forty or more at its birth. The child is quite happy with younger children but annoyed by older. His appearance, with slit-like, oblique eyes, often a transversely fissured tongue and open mouth, and a broad-based nose, fat round cheeks, lobeless ears, and coarse hair, and his affectionate nature, imitative tricks, and love of music, make a characteristic picture. These children never develop mentally, remaining about the level of four- or five-year-olds. Physically they have poor circulation and are likely to die of bronchial or tubercular disease at a comparatively early age.

Cretinism is a growth of both body and mind in a torpid kind of way, associated with some deficiency in function of the thyroid and other glands. The head is large, belly protruded, hands spade-like, and both skin and hair thick and coarse. A seven-year-old cretin looked like a seven-months-old infant, and a quaint-looking twenty-three-year-old girl was found among the babies of an infant school. In both cases regular administration of extract of thyroid gland made marvellous changes, and five years later it was discussed whether, in view of her success in the special class, the younger child might not be tried in the ordinary school. Thyroid administration, however, is very variable and often quite disappointing in its results, but always worthy of a trial.

The retardation of evolution in mentally defective children is on the average very general, although a microcephalic boy of thirteen may occasionally be found with the physique and moustache of a young navvy. Nutrition is as a rule not good, and congenital heart defects are more frequent than normal. The circulation, partly from want of proper exercise, tends to be poor; blue, cold hands with a tendency to chilblains are common; nasal catarrh originating in neglect often leads to habitual mouth-breathing, present in about half the cases; defects of eye or ear are hardly commoner than among other children, but the mental interpretation of things seen and heard is defective, and slight corneal opacities from *ophthalmia neonatorum* or corneal ulcers in babyhood are not rare. Some of the most hopeless of the feeble-minded have a spurious appearance of brightness which may deceive an untrained person. The "smiler" is well known in the schools as very unteachable. For instance, a good-looking, well-grown girl of eleven, apparently bright, whose parents contested the decision to place her in a special school, were supported by the managers and even by medical opinion, until, on being tested, she smilingly failed to count three pennies and a halfpenny laid before her. Any evidence of irregular order of mental development is strongly suspicious of feeble-mindedness.

The failure to form complex ideas or general conceptions makes abstract teaching relatively valueless; concrete examples are wanted, not only for the children in special schools but for about four or five times this number who are now in ordinary schools. Literary education, either reading or writing, beyond the mere forming of words, is generally waste of time; these children can only be "hewers of wood and drawers of water," and the simpler and more practical the scheme into which they are fitted the better for the future. Not more than one-third of the special school children contribute permanently and materially in later life to earning a livelihood. Only superstition prevents the permanent segregation, or better still sterilization before puberty, of every case that requires education as feeble-minded.

Moral Defectives.—Whilst a certain degree of moral blunting is almost necessary for the comfort of the administrative official or politician, who without great knowledge is to attain popularity by always taking the easiest course, being all things to all men, the subject of moral deficiency has been strangely neglected. When present in marked degree it becomes of high social importance. The attempted definition on p. 97 is sufficient for the purposes of the Mental Deficiency Act, 1913, but the morally defective vary intellectually from the very clever individuals, who may become millionaires or duchesses, to others who will be classed as criminal imbeciles. They may be quite modest and shy, and although usually bold and unabashed are not necessarily vain or egotistical. As in later life, many of these individuals pass through school too clever to be caught. Professor Mott has pointed out how in business the very successful self-made man often has something degenerate of this type.

The body of memories stored up, comprising the conventions regulating conduct to society in any particular country, are quite as artificial as speech symbols, and of perhaps even later evolution, and hence exceedingly variable as regards their nervous structural basis. They are no more complex than the speech memories already discussed; most of them, indeed, are mere taboos. Although the brain centre for moral conventions is not located, it is because, like the intellectual speech centres, it lies screened behind other lower centres for sensations and movements. Varying degrees of imperfect evolution here, not necessarily accompanied by any other defect, would result in individuals who were weak in appreciating moral conduct and incapable of much education in this respect, yet normal in other ways, and following behaviour in accord with lower emotions or appetites.

In one variety the emotions are relatively well developed compared with the intellectual mental control, so that these individuals are exceedingly plausible in speech, and have a peculiarly attractive gift of adapting themselves, smiles or tears being available with equal ease according to their environment. Most offend early, possibly in matters of cruelty, lying, or swindling; and girls may make themselves obtrusive even before puberty by their misbehaviour. The pure cases of moral defect unaccompanied by feeble-mindedness are usually past masters of the *suggestio falsi* and *suppressio veri*. Those with high intelligence may display almost devilish cunning in attaining their ends, but often quite futile and trivial ends. This is, indeed, one of the marks of the defect, that colossal and intricate organization and machinery may be devised apparently almost for the pleasure of constructing them.

In educational matters they can only be treated according to their intellectual capacity, although education may just mean arming them against their fellows. So long as of low grade or mediocre intellectual capacity they are comparatively harmless criminals. Society as yet has failed to control the individual who in business or official life, with colossal industry, may shine brilliantly, and yet covertly be the cause of far-reaching misery. Such individuals have still to be endured, but they should from the first moment of suspicion be carefully noted, and if possible registered by finger-prints, to deprive them of the power of utilizing with impunity the calumnies, charges, and lies which they are likely to make or use in the future.

For classification under the Mental Deficiency Act there must be—

(i.) Definite legal evidence showing not merely childish extravagances but strong vicious and criminal tendencies;

(ii.) Definite evidence of punishment having been tried and failed;

(iii.) Some accompanying, even if slight, permanent mental defect.

Epilepsy.—Epilepsy may occur as apparently a disease by itself, or a complication of other brain troubles, particularly those of a coarse kind. The cases vary in feature from quite distinguished mental workers to idiots. There is always tendency to degeneration, the *epileptic dementia*, with slow speech and difficulty of collecting and expressing thoughts, seen in chronic cases. An epileptic attack may be preceded by the *aura*, a queer feeling of some kind; then comes a sudden cry, a protracted (tonic) contraction of the muscles, with pale face, falling down, and loss of consciousness. There may be convulsion, with biting of the tongue and loss of control of the sphincters. These symptoms may be slight or violent. Fits may be at any time or chiefly in the early morning after the first sleep is over. Another form of epilepsy known as *petit mal* is not accompanied by violent fits; there may, indeed, be a momentary blanching of the face, a turn of the eyes, or a hitch in conversation, and the child is all right again. Sometimes after either form of attack a post-epileptic condition ensues, in which the child appears to do intelligent acts but is not rational. It may wander away, or it may get up in its place, walk round the class, and then sit down, or may take its clothes off. Dementia appears to come on rapidly in some cases of this last and milder form, which seems confined to highest level structures. The majority of epileptics have an epileptic heredity, and many are also said to give the reaction for syphilis. School treatment depends entirely on the effect on the ordinary school. A child having a fit once in many months may continue, but fits frequently occurring would be a cause for exclusion. Residential schools, where the child can be dieted and have suitable work, are the best. It is suggested that stairs should be avoided in these schools, but this is not absolutely necessary. The harassment in life to a family in a small house from having an epileptic child with nocturnal fits is frequently heard of in school, and if for this alone the residential school should be urged for most cases. These children should be educated particularly with regard to their defect, which makes them unreliable and prevents them following occupations in traffic, or among machinery, or water. Plenty of muscular exercise and an avoidance of much meat in the diet is generally recommended. Otherwise the hygiene is similar to that of other residential schools.

CHAPTER VIII

THE BINET-SIMON MEASURING SCALE FOR INTELLIGENCE

THE examiner requires some experience and practice before using this scale in order that his work may be scientifically recorded. He must remember that he has not to get results out of the child, or educate it; he must be quite unbiased in recording, must avoid influencing its judgment, and must appear pleased with whatever result is obtained. The child should understand the examiner, and for this purpose he should approach it on the mental level of a child. The child has the mental level of the highest age for which it has succeeded in doing all the tests; after that it is advanced by a year for every five tests higher than that age-level in which it was wholly successful. The picture test is perhaps easiest to begin with. Showing this, the question is asked, What do you see here? Avoid leading questions which might suggest a reply, such as, What is this? or, What are they doing?

Since the early death of Binet, the tests have been somewhat modified by Goddard to suit English-speaking children. The following tests should be managed correctly at the ages mentioned. It should be remembered that schooling in France does not begin till a year later than in England.

Children of three years old.

1. *Where is your nose? your eyes? your mouth?* It is sufficient if these are correctly pointed to.

2. Repetition of six-syllable sentences, e.g. *It rains. I am hungry.* There must be no error. The child of three repeats six but cannot repeat ten syllables.

3. Repetition of two figures. Slowly repeat "*Seven—five.*"

4. Describing pictures. *What do you see?* The three-year-old mentions things without describing actions.

5. Name of family. All three-year-olds know their Christian name and most their family name.

Four-year-old children.

1. Sex of child. *Are you a boy or girl?* Three-year-olds do not know, four-year-olds always know.

2. Naming familiar objects. A key, a knife, a penny are produced from the pocket.

3. Repetition of four figures.

4. Comparison of two lines. *Which is the longer?* There should be no hesitation as to which is the longer of two parallel lines, about 3 cm. apart and 5 and 6 cm. in length, drawn on a card.

Five-year-olds.

1. Comparison of two weights. *Which is the heavier?* Weighted wooden blocks of equal size, 3 grams compared with 12, and 6 with 15.

2. Copying a square in ink. A square of 3 or 4 cm. side is shown drawn on card.

3. Repeat sentence of ten syllables, e.g. "*His name is John; he is a very good boy*"; or, "*Little Mary likes to play with her dolls.*"

4. Counting four pennies in a row. At four half, at five all should succeed.

5. Game of patience with two pieces of card. The backs of pieces of a visiting-card cut diagonally; ask the child to place them as uncut card shown.

Six-year-olds.

1. Distinction between morning and afternoon. *Is this afternoon or morning?* in the afternoon; reverse in the morning.

2. Definition of objects. *What is a fork, a table, a horse, a chair, a mamma?* Three out of five are correct. The definitions are given by use. Variations are *spoon, bed, drum, cow, father.*

3. Execution of three simultaneous commissions, e.g. "*Do you see this key?—put it on that chair, then shut the door, after that bring me the box on the chair. Remember, first the key on the chair, then shut the door, and bring the box.*" Half do it at five, nearly all at six.

4. Right hand, left ear. "*Show me your right hand,*" then, "*Show me your left ear.*" At four, none point to the left ear; at five, half; at six, all.

5. Æsthetic comparison. Three pairs of pretty and ugly faces are shown, and *Which is the prettier?* is asked. About half are right at five and all at six.

Seven-year-olds.

1. Counting thirteen pennies in a row. Two-thirds fail in six-year-olds, but all succeed in sevens.

2. Description of picture. Description now instead of enumeration of objects.

3. Unfinished picture. *What is left out in this picture?* Some sketches of persons or heads with eye, nose, mouth, or arms missing. None correct at five, one-third at six, nearly all at seven.

4. Copying a diamond shape with pen and ink. The diamond is a rhombus of 3 or 4 cm. side drawn on a card shown.

5. Name four colours. Red, blue, green, and yellow slips of paper about 2 by 5 cm. are shown and touched by turn. *What is that colour?*

Eight-year-olds.

1. Compare two things from memory, e.g. "*What is the difference between a butterfly and a fly? between wood and glass? paper and cloth? horse and cow? stone and egg? grass and tree?*" Two of the three asked should be answered in a couple of minutes by all eight-year-olds, nearly all sevens, and one-third of the sixes.

2. Count backwards from 20 to 1. This should be done in 20 seconds without more than one correction.

3. The days of the week. Should be given correctly in 10 seconds.

4. Count nine halfpennies, three single and three doubled. Many do this at seven, all at eight.

5. Repetition of five figures. Only three-quarters succeed.

Nine-year-olds.

1. Giving change. Coppers (pennies and halfpennies) equal to a shilling are given to the child; he is then offered a shilling and told to take fourpence-halfpenny out of it and return the correct change.

2. Definition better than use for common objects. Half the children of seven and eight, and all at nine, define by better terms than the use of objects.

3. Name the day of the week, the month, the day of the month, and the year.

Allowance of three days is made for error in date of the month.

4. The months of the year. These should be given in 15 seconds without more than one correction or mistake.

5. Arrangement of weights. Small equal-sized boxes loaded with shot to 6, 9, 12, 15, and 18 grams. In three minutes three trials are made and two must be correct.

Ten-year-olds.

1. Name nine pieces of money.

2. Draw design from memory. A simple design is shown for 10 seconds. It may be held vertically or reversed.

3. Repeat six figures.

4. Questions of comprehension (first series).

E.g. *What ought you to do—*

(i.) *When you have missed the train?*

(ii.) *When you have been struck by a playmate who did not do it purposely?*

(iii.) *When you have broken something which did not belong to you?*

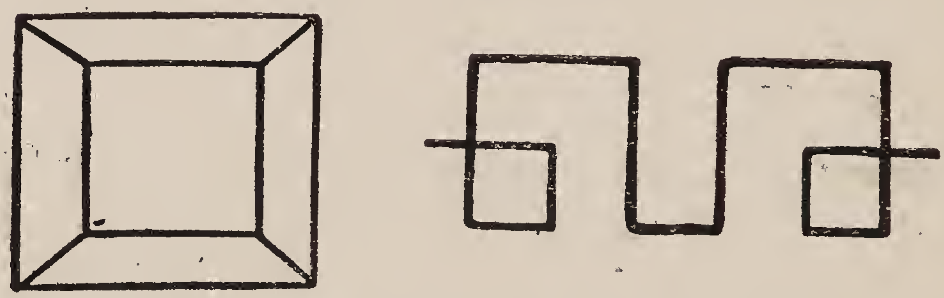


Fig. 14.—Two of the designs used as memory tests of form for ten-year-old mental level.

If two out of three are answered it is a pass. Half succeed at seven and eight, three-fourths at nine, and all at ten.

What ought you to do (second series)—

(i.) *When you are detained so that you will be late for school?*

(ii.) *Before taking part in an important affair?*

(iii.) *Why do you excuse a wrong act committed in anger more easily than a wrong act committed without anger?*

(iv.) *What should you do when asked your opinion of some one whom you know only a little?*

(v.) *Why ought you to judge a person more by his acts than by his words?*

Three of the five must be correct; 20 seconds allowed for each. Only half are successful at ten and none at seven or eight.

5. Using three words in a sentence, e.g. *London, money, river.*

A single sentence or two sentences united by a conjunction are correct, but three sentences are wrong. At ten half, nine one-third, eight none are right.

Eleven-year-olds.

1. Criticism of sentences. "*I am going to give you some sentences in which there is some nonsense; listen carefully, and tell me where the nonsense is.*"

(i.) *An unfortunate cyclist has had his head broken and is dead from the fall; they have taken him to the hospital, and they do not think that he will recover.*

(ii.) *I have three brothers—Tom, Fred, and myself.*

(iii.) *The police found yesterday the body of a young girl, cut into twenty pieces; they believe that she killed herself.*

(iv.) *Yesterday there was a railway accident, but it was not serious; only forty-eight people were killed.*

(v.) *Some one said, "If in a moment of despair I should commit suicide, I should not choose Friday, because Friday is an unlucky day, and would bring me ill luck."*

Three at least should be well answered by half the children, by about a quarter at ten, and scarcely any at nine.

2. Three words in a sentence. (As in Question 5 of ten years.) At eleven all succeed.

3. Sixty words in three minutes. Having told the child that some children have said two hundred words, the observer now orders him to "*Say as many words as you can.*"

4. Rhymes. Three rhymes should be found for a word —e.g. day, spring, mill—in one minute, after explaining and illustrating what a rhyme is.

5. Words to put in order. *Make a sentence out of these words: Started—the—for—an—early—hour—we—country at. Asked—paper—the—to—I—teacher—correct—my. A —defends—dog—good—his—master—bravely.*

Showing the printed words of a sentence at a time, the child should give an oral reply for two.

Twelve-year-olds.

1. Repetition of seven figures.

2. Abstract definitions. "*What is Charity? Justice? Goodness?*"

3. Repetition of a sentence of twenty-six syllables.

(i.) *Children, it is necessary to work very hard for a living; you must go every morning to your school* (24).

(ii.) *I saw in the street a pretty little dog; he had curly brown hair, short legs, and a long tail* (25).

(iii.) *Ernest is praised very often for his good conduct. I bought at the store a beautiful doll for my little sister* (28).

(iv.) *There occurred on that night a frightful tempest with lightning. My comrade has taken cold; he has a fever, and coughs very much* (30).

4. Resist suggestion. A little booklet of six pages is prepared. Two horizontal lines are drawn in the same line

on the first page, with a half-inch interval between the central ends, the right one being 2 and the left one 2½ inches long. On the second page they are 2½ and 3 inches long, on the third page 3 and 3½ inches, and on the remaining pages all are 3½ inches long. On the first two pages it is asked, "*Which is the longer line?*" for the others "*and there.*" It is noticed whether the suggestion of difference persists.

5. Problems.

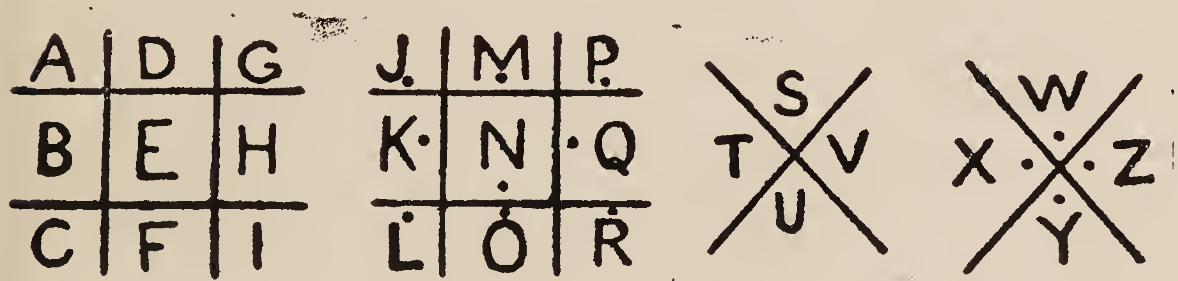
(i.) "*A person walking in Epping Forest suddenly stopped, much frightened, and hastened to the nearest police station and reported that he had seen hanging from the branch of a tree a—what?*"

(ii.) "*My neighbour has been having strange visitors. He has received one after the other a doctor, a lawyer, and a clergyman. What has happened at the house of my neighbour?*"

Fifteen-year-olds.

1. Should interpret the picture, using words expressive of emotion.

2. Change the hands of a clock. Without seeing the clock-face the child is told to think of a time, such as twenty minutes past six, and then asked what would be the time if the hands were changed about, minute hand for hour hand, and *vice versa*.



3. Codes. A diagram as above is constructed, whilst the child looks on; he notes the arrangement of the letters

in vertical rows and against the clock, and the dots used in the second and fourth. Once the scheme is known a cipher can be constructed by using the parts of the diagram nearest the letter without the letter; thus "war" would be written . He is then asked to write a short sentence of one or two words without seeing the diagrams or drawing them, and purely from memory.

4. Opposites. The child is asked to write the opposites of a number of words, e.g. good, tall, rich, thin, war, friend. Nineteen words are given and seventeen should be correct.

CHAPTER IX

THE PHYSICALLY DEFECTIVE

The ambulances of the invalid or cripple schools are now seen in all large towns. The schools are established under the Elementary Education (Defective and Epileptic) Act, 1899, quoted on p. 98; originally intended for cripples, their scope has been widened and extended as the result of experience. There is also a greater readiness of doctors to advise attendance at such a school, rather than to give certificates invaliding over long periods. Children are admitted with any chronic disease or crippling deformity when unable or unfit to work with healthy children in the ordinary school. The bulk of the cases will be children with tuberculosis of the spine or joints, paralysis, or heart disease. Certain cases of chronic or relapsing rheumatism or chorea, asthma, chronic bronchitis, exophthalmic goitre, or hæmophilia are also suitable. The education in such schools is inevitably costly, and admission should be refused to unsuitable cases even if physically defective, such as children with hernia, chronic renal disease, trivial deformities, and compensated heart lesions without symptoms, which under the school doctor's supervision do as well in the ordinary school. Epileptics should be excluded as detrimental to other scholars, if not to themselves, and also children objectionable in respect to habits, discharges, or dirt. Cases of progressive paralysis are rarely worth educating. Children with early pulmonary tuberculosis should be reserved for residential country or open-air schools.

Mental defect to any notable degree is a reason for exclusion, as the child cannot take advantage of the education offered. Allowance must be made for the fact that invalid children are usually very backward. They have been deprived for months or years not only of schooling but of the companionship of other children, and contact with the illuminating life of the streets. A spurious feeble-mindedness may even be induced, especially in tubercular or paralysed children, which may take months to clear up.

After entrance each case should undergo full examination by an expert, to determine the nature of the work to be done and the probable course of the case. Physical exercises are practised as far as possible, having regard to the defects. The children are taught to take their drawbacks philosophically, and not to regard them as an excuse for evasion of duty or appeal to sentiment. Much importance is attached to development of any artistic sense and to handwork. The older children should be trained for selected occupations requiring brains rather than physical exertion; such are designing, bookbinding, fine mechanical work, jewellery, watch-making, etc., for the boys, and certain kinds of domestic service and the lace and needlework trades for the girls. It may be expected that from 30 to 40 per cent. of all the pupils will never be fit for industrial employment, though nearly all can be trained to do work in their own homes which, if not remunerative, at least fills out and broadens their lives.

Hospital operative treatment on the crippled cases is functionally usually comparatively ineffective in its later results. The children recover better if able to spend the first year after operation in a country school of recovery. The pattern school is at Chailey, in Sussex. Heart disease accounts for half the deaths among these scholars, and is, indeed, the commonest cause of hospital deaths between the ages of eight to fifteen years.

Schools for the physically defective should be one-storied buildings constructed on open-air principles, with verandas and large French windows opening without steps on to the playground. Good space for play is needed, as much time should be spent outside. The classes should not have more than twenty pupils. The hours may be 9.30 till 4.30, as the school conditions are not heavy and generally more hygienic than the home. Midday dinner must be provided for all the children, with a liberal and varied diet, including ample meat, stewed fruit, and fresh milk. School baths are very desirable.

CHAPTER X

BLINDNESS

Many become blind through the incidence of disease in adult life, but they cannot be compared with those blind from an early age, who are rarely other than socially dependent. Although each blind child costs some three hundred pounds or more for education, this helps towards making them self-supporting. The Elementary Education (Blind and Deaf) Act, 1893, defines a blind child for educational purposes as "too blind to be able to read the ordinary schoolbooks used by children." This test of blindness is simple; it includes not only the truly blind, but also the semi-blind with very defective vision, and high myopes who can see well but would suffer from ordinary schoolwork.

The truly blind perceive no light, although many have the power of orienting a light or shadow which extends to or above the level of their head by what is termed *facial perception*. Those are also counted as practically blind who perceive lights and shadows up to making out the movements of a hand or even counting fingers within a metre off. The age recognized for school attendance is from five to sixteen.

For the blind, literary work is managed by the tactual impression of raised dots. These up to the number of six in certain positions constitute the Braille alphabet, and can be used for reading and writing. The sensibility of the finger-tips is not greater than is found among normal children, but the mental interpretations are enormously heightened by education. Chilling or coldness diminishes this sensibility, so that the classrooms must not fall below 62° Fahr. For the same reason debility and poor circulation must be guarded against. Poor physique is common, and physical exercise and respiratory training is needed. There are various habits, especially the deportment in sitting and walking, which require attention. Personal hygiene is often defective, and tendencies to fingering and picking eyelids, nostrils, or ears, and to rhythmic movements often require prevention. It is obvious that teachers must be sighted, but vision such as myopia over 4 diopters, or diminished visual acuity, $V = \frac{6}{24}$, which would prevent teaching work in an ordinary school, may be permitted in blind schools.

There are perhaps two thousand blind children being educated in this country, but probably half this amount will be replaced by semi-blind in a few years. The causes of blindness will also vary relatively, with time. When the Act of 1893 was put into force, the results of *ophthalmia neonatorum* accounted for 40 to 50 per cent. of the pupils. This disease, a purulent inflammation of the lining membrane within the eyelids occurring in infants during the first week of life, was lately made notifiable, which will result in a great decrease in juvenile blindness.

Other causes of blindness in children are congenital deformities of the eyes; and defects, especially cataract, and atrophy of the optic nerves, often due to inherited syphilis: these account for about 20 per cent. There are also preventable causes arising from ulceration leaving opacities, inflammations from inherited disease, catarrhal infections, or contagious disease; these perhaps make up 10 per cent.

Blind-school pupils should have a detailed ophthalmic examination recorded at least once a year. Pain and suffering may often be relieved, possibilities of some visual improvement detected; and even where eyes have been removed the condition of the sockets needs watching, especially as any discharge may be contagious. Those wearing artificial eyes or shells should be especially instructed in their care and use.

Myopia Schools.—A large miscellaneous group suffering with permanently damaged eyes or diseased conditions, who may be actually harmed by ordinary schooling, come under the definition of the Act as educationally blind. Children with diminished visual acuity, seen in cases with corneal opacity; with chronically recurring phlyctenulæ, who should be at the seaside; with interstitial keratitis, old choroiditis, high myopia, congenital cataract, dislocated lenses, congenital absence or deformity of iris, some albinos, and some children with nystagmus, make up a group more numerous than the blind, but from the results to be obtained more worth educating. Cases of advancing myopia in young children should be included. The schools for these pupils, first started for high myopes, are known as *myope schools*. They count with blind for grant purposes. They have chiefly oral teaching, for which they attend the elementary school. The pupils are not allowed to look at any book or write on any paper. Literary work is entirely done in large broad-lined letters on the blackboard, or hand-printed in letters about 2 inches square with india-rubber-faced types. Manual occupations like cookery and carpentry are useful. Plenty of physical exercise is encouraged, although some of the myopes have to be warned or even withdrawn from these lessons for risk of retinal hæmorrhage or detachment. Lessons are correlated as far as possible, e.g. a child listens to an oral lesson on history or geography at the ordinary elementary school, and reproduces at the myopic school what he has been taught by means of large sketch maps, or composition, according to the text of the lesson.

Children are found who, where there are difficulties in attendance at such a school, should be permitted to attend the ordinary school under restrictions rather than be invalided.

Oral teaching only should be employed for such children, chiefly myopes, as must not be allowed to use books, paper, pens, or pencils. The children should frequently be reminded that the restriction is only for their own good and to preserve their vision till they grow up, and that certain things are equally important to avoid out of school as in school.

Easy treatment, when suggested to the teacher, should mean seating the child in the front row of the class and preventing it bending over any work. Girls may do knitting by touch, but must not sew. Books with small print must be prohibited and only a bold handwriting without lines permitted. No exercises involving reading or writing of masses of figures or geometrical diagrams are allowed. Reading large-type books for not more than twenty minutes at a time may be permitted, and home lessons are to be prohibited. Drill, dancing, games, all object-lessons, demonstrations, and oral lessons should be attended.

CHAPTER XI

DEAFNESS

The special education of the deaf is provided for under the Elementary Education (Blind and Deaf) Act, 1893, the definition, as in the case of the blind, being drawn on a wide and practical basis as those "too deaf to be taught in a class of hearing children in an elementary school." Schools are not to be considered as in any way connected with the institutes for the deaf, which have established financial interests in philanthropic and charitable aid, and which not only destroy much of the results of education, but in tending to segregate the deaf rather do educational harm, apart from their bringing congenitally deaf people together in a dysgenic way that frequently results in a further propagation of this trouble in the next generation. It is only in the last four or five years of school-life that the residential school training in manual and trade work overbalances the disadvantage of removal from the natural education by contact with everyday life in the home and street. The home should help the school. About 15 per cent. of the congenitally deaf-mutes have inherited their defect, and there are probably ten thousand people in this country either deaf, or the children of deaf, who can transmit the defect, and who, if they should marry a similar or related individual, may have deaf families. This statement might also be extended to include the degenerative conditions of congenital cataracts, *retinitis pigmentosa*, and mental deficiency. There are some reasons for supposing that most of the other cases of deafness appearing soon after birth are the result of inherited syphilis.

A child learns to speak in its second year of life, but if hearing be lost before the sixth or seventh year speech will go too, unless pains be taken to preserve it. The deaf child should learn speech as soon as possible: education must begin at three, although the compulsory age is not till seven; indeed, the first question of educational importance asked is "When did the child become deaf?"

Half the children in deaf schools are not those very early cases, but have acquired disease chiefly through destructive inflammation of the middle ear with suppurative discharge. This may begin acutely as a result of the zymotic diseases, especially in children with naso-pharyngeal obstruction, but it also occasionally occurs as a result of catarrhal conditions from such obstruction. The last class are chiefly children with some hearing, and about a third of the number can be materially relieved by suitable treatment. A girl of twelve, for instance, deaf to the ordinary voice for several years, after mastoid operation heard a forced whisper across a large room at 10 metres.

Careful otological examination is necessary in every case, and the success of operative treatment is so great in saving some hearing that few scars of mastoid operations are seen in the deaf schools.

The next important question asked is "How much hearing is left?" The deaf may be stone-deaf, hear noises, vowel sounds, or actual words. In testing children, those who hear the ordinary speaking voice over 2 metres are fit for the elementary school; between 1 and 2 metres they should try the front row of the school class; below this, to half a metre, a "hard-of-hearing" class is most suitable; if this cannot be attended, then the deaf school.

In middle-ear deafness, acuity to whispered speech is often lost before noticeable deafness to the speaking voice comes on. The detection of this loss, and immediate medical treatment, would lessen the number of cases of deafness, especially in later life. Many cases of catarrhal deafness originating with enlarged tonsils and adenoids come on insidiously, sometimes with noises in the head, and lead to slowly increasing deafness, characterized by hearing better in a noise, in the third decade of life.

The forced whisper—that is, voiceless articulation after expiration, using only the residual chest air—should be heard by a normal child, in a quiet country playground, at 20 to 24 metres, with the eyes covered, and 4 or 5 metres further if eyes are open. It is a serious mistake for official records to be accepted as normal under a third of this distance. A child who does not hear the forced whisper at 2 metres is hard of hearing, and requires special education, and if it is a congenital case without speech, it should be trained in a deaf school. Some very deaf children with good intelligence get along surprisingly well. A small girl of about eleven, sent up as very hard of hearing to be admitted to a deaf school, had already got on to doing algebra at her ordinary school, and although a congenital case, scarcely hearing the ordinary voice across a table, she was returned there. The deaf child should always attend the highest grade of hearing school in which it can progress. The older children should be gathered where manual and trade instruction can be given. Tailoring, shoe-making, carpentry, and graphic arts do for boys, but apart from work as engravers, metal work and agriculture appear unsuitable. Girls make good dressmakers and laundry workers of the best kind. The deaf child suffers from deprivation according to the depth of its defect, so that a deaf-mute of sixteen is mentally on the level of a normal twelve-year-old. These children are usually more attentive and sharper observers than ordinary, although in the ordinary school the less deaf among them seem to become inattentive from the fatigue of straining to hear.

Good vision is so important to the deaf that every attention must be given to getting full value, by correction with glasses, by preventing external ocular diseases, and avoiding strain. Fine work like writing or sewing should be scrupulously avoided before the age of ten years.

Hard-of-hearing classes, as already indicated, have been started for the semi-deaf, some of whom are now found among the pupils in deaf schools and more in the ordinary schools. They retain the power of hearing words or even short sentences. Most will never become totally deaf, and many will, with the aid of training and apparatus, retain or improve their speech and mix with the general population. Training in lip-reading, articulation, and voice production is essential, and many after a few months should return to the ordinary school, at which, indeed, they generally attend for many subjects. The classes, although officially counted as deaf, should rather be in connection with the ordinary schools than with the deaf. Where tried, the scholastic results, and the improvement in brightness and tone of the children, have been remarkable.

So far it has been assumed that the deaf are mentally normal and capable of learning oral speech. It is wrong not to attempt this for all. Many will learn badly, but will understand and be understood by those with whom they come in daily contact. A few cannot learn sufficiently; they are about 10 to 20 per cent. of the deaf, and, as a rule, are mentally defectives who happen to be deaf, and should be removed to other institutions, rather than be taught by manual alphabet signs in an oral school.

Combined Defects.—The combined defects of blindness, deafness, mental or physical defect are so rare that each case must be individually considered. In all cases the mentality is the first thing that counts. A few cases occurring late in school-life, where defective vision from interstitial keratitis is accompanied by deafness, are due to inherited syphilis. They are not satisfactory as a rule, and do not require special education, but sometimes exclusion as invalid. Total deafness or blindness is exceedingly rare as a result, and often some improvement by treatment is obtained in the visual condition, but rarely in the hearing.

CHAPTER XII

THE SCHOOL PROGRAMME

A STUDY of the physiological and experimental facts given in Chapters I and II suggests important practical lessons as to schoolwork.

The school year is divided into terms by the holidays. These holidays are necessary for mental and bodily recuperation. Certain fatigue effects, particularly subjective feelings, become evident to both teachers and pupils during the term. There is also a notable increase in anæmia, especially as a result of examinations. This subject, however, needs investigation with respect to work and season.

Holidays appear to have been determined by religious festivals and the harvest. The harvest holiday, established before stage-coach days, is nowadays often wastefully long, and a month is abundant change for schools, or for professional men who are not becoming senile. The holidays of a fortnight at Christmas and a fortnight at Easter are of such value that they should never be curtailed. The long stretch through September to December requires a holiday of a week, or better ten days, about the middle of October. Allowance is made in the Code Regulations for holidays up to twelve weeks. The usual amount in the elementary schools does not exceed eight weeks. With the intensive nature of teaching work and the worrying and harassing detail to attend to constantly in administration, this is not an excessive amount of holiday, and in view of the steady increase of neurasthenia at earlier ages among teachers a midterm autumnal holiday is almost a hygienic necessity.

The school week is of ten sessions. In elementary schools it is the rule to keep Saturday free. This is recommended for all day-schools, unless an abundant facility exists for games; in this last case, and in residential schools, there is advantage in working on Saturday morning and setting one other afternoon free.

The school day is generally two sessions, separated by a couple of hours from 12 till 2 p.m. for lunch. It is not quite certain that this is the best arrangement. At Halle, observation by a very acute worker showed that with children working the same number of hours daily, those who worked double sessions continuously had much less sickness than those who worked both morning and afternoon sessions with a lunch interval between. With an afternoon session from 2 till 4.30 p.m., the latter part of the day is often dark in winter, and in country districts not safe for young children to return home. In summer, again, the last hours of the afternoon may be exhausting from heat, particularly in the usual small, ill-ventilated classrooms. With the introduction of a school midday meal as part of the educational provision a double session has advantages and economy, except in manufacturing districts, where the women minding machinery need to have their own children minded.

The Duration of Lessons.—The efficiency of a lesson depends on maintaining the attention of the pupils and giving them opportunity to inwardly digest it subconsciously. Attention markedly diminishes in half an hour, but this depends also on the nature and mode of work. With a lesson properly broken up, explanations by teacher, desk work, and spontaneous hand work or blackboard work, all intermingled the duration might be longer than a continuous lesson of writing or reading. Laboratory and manual work, which have a variable and intermittent quality, can go on for longer still. Every lesson which lasts over forty minutes should have at least one break of three or four minutes, for some quick, coarse, and massive muscular exercises, to stimulate the heart and promote lively blood and lymph movements.

It is worth trying to realize the hygienic value of the fundamental schoolwork. Writing can be used as an illustration of how educational methods may be influenced. The learning of letters and writing, being without much intellectual content, is usually a very tedious task to intelligent children, many of whom do not put forward the effort to acquire a good hand. Although generally taught as a visual performance, this is objectionable for ocular reasons. The eye only being necessary to keep the lines straight, writing should be learned by muscular sense, as a typist learns to work without looking at the keyboard. It is further so trying as a fine finger exercise that small writing should only be permitted under restrictions before nine or ten years of age, and as a definite writing exercise with pen and paper wholly prohibited before seven years of age. If there is to be any copybook work it must be letter elements of considerable size and very rapidly done. Slow work is not good here, and small-text writing should only be permitted with a covered pen-point. No letters are to be made less than 3 millimetres in height; the relation of spacings should approximate to those of print. Dotted lines distract or strain the eyes, and only very thick guide lines are permissible midway between the lines of script, and not to be touched by any letter; they are merely for orientation of the words. With a book thus ruled good writing can be done, the letter in formation being hidden by the pen-nib being thrust through a paper shield the size of a penny. Writing thus learned may be expected to be better than that visibly done. This unseen test of whether writing has been properly taught as a subconscious muscular action is reliable, and yet how few eight-year-olds could be found able to write their names in letters the size of their hand on the blackboard with closed eyes. Manual work is of importance because it brings into activity the motor centres of the brain, besides giving dexterity and skill. It also forms a means of educating and developing other centres indirectly, because no manual work can be done in a spuriously accurate way; there

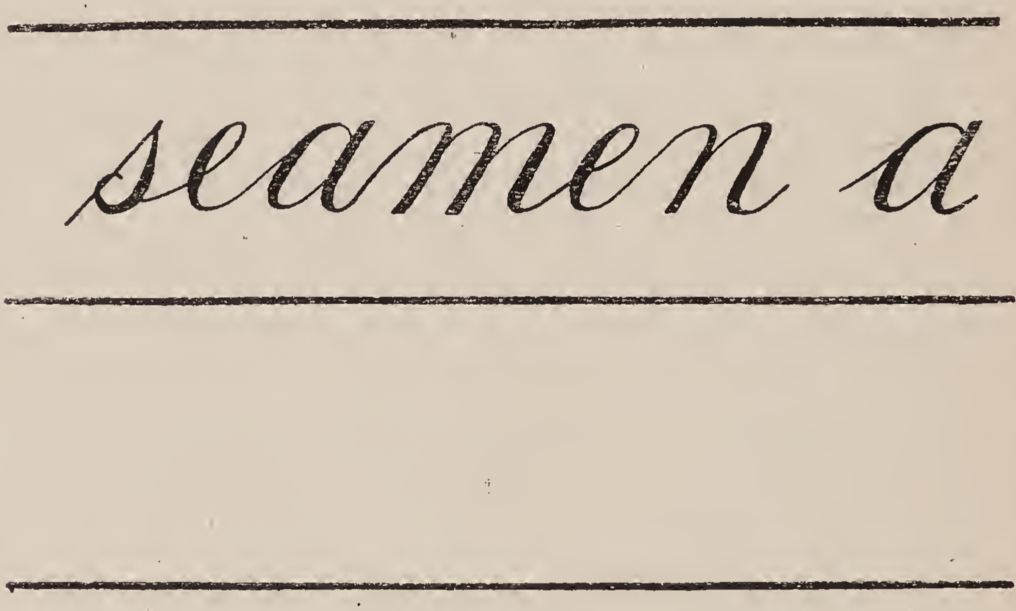


Fig. 15.—Orienting lines for copy-book for young children.

is none which does not call for careful estimation and accurate judgment. Many retarded children, on coming in contact with manual work which provides as it were access to the highest levels through the motor areas of the brain, often undergo a most unexpected acceleration in mental development. To learn by doing should play a preponderating part in the education of retarded children, if not of all, and especially, too, in any intermediate schools. This is not the place to dwell upon the full educational extension of manual work as set out by Kirschensteiner and others.

From the hygienic point of view, however, there should be a continuous scheme, from the sticklaying of the infants up to forms requiring the slide-rule and graphs among the elder boys.

Discipline and punishment are extremely difficult for any one to speak of who is not actually handling children. To say that no corporal punishment is to be used, and that a teacher who cannot succeed with kindness and appeals to reason is not efficient, betrays ignorance of a large number of children. There are all varieties in the natural age levels and in gifts, so that children vary from imbeciles to geniuses, and from an intellectual level below that of Hottentots to the highest; were teachers too all of equal mental level, this statement would be enough. They would recognize the aggressive little savage only to be controlled by appeals to common sensation as speedily as they would know the sensitive, emotional, but passive and undeveloped child, and make the proper appeal to it. The majority fortunately can be won over by such emotional appeals, either by kindness or respect for their personality; whether such emotional appeal is always good, even if successful, is not beyond discussion, but there is a very variable remainder in which the correction to be applied must be Nature's most elementary method—that is, the fear of physical pain; as Stanley Hall has expressed it, "some need the training of fear, some of anger." No teacher is justified in inflicting punishment unless satisfied that the perversity or unruliness of the child is not merely the reaction of starved nerve centres through their want of exercise or want of food. City children with practically no freedom for play, bad-tempered, quarrelsome, and peevish, become, when taken out of the classroom into the open air, for a few weeks even merely in a playground class, cheerful, smiling, happy, and companionable, and a cup of milk, with its important vitamines, or a good meal daily, often works wonders in those who do not come along with the others.

The effects of rheumatism, and particularly the early stages of chorea, are manifested by strange irritability, sometimes even irrationality of conduct. It is not only ill-nutrition which accounts for nervous reaction of this type: the "nervous child" often reacts to effort by exhaustion and irritability, so that it shows school anxiety or worry in one direction, plays truant, misbehaves, or makes many working mistakes in the other.

A child should not be punished who shows signs of nervousness in that it bites its nails, or has twitching about the face, or has fine tremor in its extended fingers. Corporal punishment should be quite rare above eleven years of age, and almost forbidden above about thirteen, when the enormous psychical change or development in children begins. Although young children may be none the worse for physical punishment proportioned to the child and the crime, any excess of entries in the punishment-book may mean that the teacher should see a doctor.

Examinations are chiefly sources of danger to older scholars, especially when they are of a competitive character, bringing into action the force of emulation. Girls are peculiarly prone to suffer when subject to competitive examination. The best results of a teacher's work, especially his personal influence on the training of mental or moral powers and the influence of an upright and consistent example, can, however, never be brought to the test of an examination, although, speaking generally, well conducted examinations, as at the University, give a fair idea of the candidate's capacity. The general impression of an answer is superior to detailed marks. The method of assigning so many marks to each possible part of an answer is utterly bad, and only excusable on red-tape lines, giving an easy but spurious assessment of the candidates. Actual results of work done in examinations are below work done in ordinary routine, and handicap the weakest most, there being up to 30 per cent. of falling off.

For elementary schools, the less of formal examination the better; even in awarding scholarships other things than mere written answers should weigh. With fixed age-limits, Jewish children, as already mentioned, are likely to gain scholarships far in excess of their subsequent performances, owing to their twelve to eighteen months' physiological precocity over English children; height and weight should be handicapped for each age.

Beyond the elementary school, examinations, if properly conducted and not too hard, should be a tonic to the scholar, as interesting and exciting as the race to the athlete. The astute examinee even accumulates much examination lore in the way of acquiring marks.

Where much is made to depend upon the result, and where the examinations are prolonged over days or weeks, the strain may be severe. Measurements of Russian students showed increasing anæmia, loss of appetite and great loss of weight during their six weeks of examinations, and the constantly increasing suicides of young people in Germany, Austria, and Russia form a statistical protest against the examination system and its importance in these lands.

CHAPTER XIII

THE TEACHER'S HEALTH

The teacher's profession is one of the sheltered occupations. The results are shown in long lives, for in the mortality statistics it ranks next to the clergy, and far beyond that of the medical man as conducive to length of days. The national value of teaching is daily gaining in appreciation, but there is a satisfaction and reward in the daily task far beyond that of most occupations. To see the result of effort, to find out how it may be improved, to trace causes and effects, make this a profession that to the interested and earnest worker brings a continuous opportunity of self-expression and of satisfaction in doing. This method of approaching and dealing with the daily task has also an enormous personal hygienic value, and reacts in the whole bearing and social relations of the teacher. On the other hand, the teachers who lose interest, and who come to work by routine and rule of thumb, soon begin to think of themselves and to feel strain. There are very real difficulties in the organization of such an extensive profession, but at the same time the tendency is more gradually extending to give a teacher a freer hand, and to allow great latitude in work. To have a good teacher and get full expression from the work there is, so far as the writer can judge, a considerable necessity to do more to raise them above, and make them feel safer from, the cares of daily existence.

The teacher's health, unless his work is carried out under the best conditions, is more apt to suffer from overwork than the scholar's. The strain upon his strength, bodily and mental, is greater, and he probably has much less variety of occupation than his pupils. This is particularly so when he teaches special subjects.

The actual facts imparted in school are of almost secondary importance compared to what the child picks up otherwise. The conduct and personality of the teacher and influence of childish companions have a more powerful influence on the child's future than any subject taught. Without this *tone* our older foundations would be poor as educational institutions. There are, or were, teachers whose rooms children visit with fear. School anxiety is a real thing to many pupils as well as masters, and a nervous, overpressed, and irritable teacher, a teacher for whom one can do nothing right, or even a teacher with a strident voice or an untidy dress, may cause trouble to a pupil. The wisdom of Terman's words in his little book on *The Teacher's Health* makes it worth study by every one engaged in schoolwork. He speaks of the mental fixation due to monotonous repetition of elementary activities under conditions of strain, which prevent other lines of mental functioning. One of the earliest symptoms of the protracted nervous overstrain is the elimination of interests which do not contribute directly to the day's work; one after another is lopped off till life is stripped; the mind narrows, becomes mechanical, and loses humanity. Recreation should become the teacher's religion, mental creativeness should be sought in some form, or fixation and early decay is certain.

A teacher almost lacks time to attend to the higher aspects of work in the elementary school. Indeed, a teacher with views is too often regarded as a nuisance by those outside the school. A few are developing what is called Child Study, but the majority are comparatively passive and appear to have lost freshness and originality. Teachers should make themselves heard in every aspect of school-life. School hygiene is of vital importance and a subject on which many of the best writings abroad are by those who are, or have actually been, teachers. It is only when the profession can speak with authority and knowledge above mere opinion that real professional freedom will be attained.

As a class the teacher is long-lived, and, as stated, only surpassed by the clergy, and far ahead of doctor or lawyer, and yet among teachers individuality is largely destroyed, and they become to a great extent mere machines, suffering considerably from non-fatal illness, and often having a depressing instead of an uplifting influence in social life. The side of the profession most impressive, however, to the doctor is the one which shows strain and its effects in breakdown, and although this may give a serious bias to his views, he is none the less able to utter warnings about the risks.

The profession is selected carefully, both mentally and physically. The mental strain of study on narrow and regulated lines in a candidate for the profession has much to do with mental sterility in later life. Medical examinations have to be submitted to on commencing studies and on finishing them. No one is a suitable person for this work who is not thoroughly healthy; any defect or deformity which would interfere with physical exercise or blackboard work is inadmissible. A stature of over five feet is necessary to see over the class. The slightest articulatory defect, lisp, stammer, or want of control of the voice is objectionable. Normal vision with glasses is necessary, but even then people with glasses for spherical refraction above 3 diopters, or more than 2 diopters of astigmatism, should seek other work. The slightest suspicion of any weakness of the chest makes avoidance of the profession desirable. The heart must be quite normal. No defect of hearing or aural discharge is safe, and those with good but variable hearing, particularly with occasional noises in the head, are very likely to find by thirty years of age that schoolwork is difficult for them. Neurasthenic symptoms during training should lead to unhesitating rejection in the candidate's own interest in later life.

Phthisis or consumption is supposed to be the great danger. Looking to the medical selection made, an excessive proportion suffer, although low in mere numbers compared with other occupations. With pulmonary phthisis a teacher should be excluded for twelve months from any schoolwork. Even if not dangerous to others, this offers the greatest hope of recovery. The best and cheapest course would be for the State to put the phthisical teacher at once permanently on half-pay. However well, no phthisical teacher should return to school if sputum is still present. Indeed, any teacher attacked by phthisis, however sound he may seem to have become, would be wise in his own interest to sacrifice prospects and, changing his occupation, to decide never to work in school again.

Neurasthenia is rapidly becoming a bugbear to the profession. It may show itself early and be got over for years, but the serious form begins later than thirty-five years of age. The absence of rest or relaxation during school hours, the continual examining and judging things and acts, leads to strain, which at first becomes evident in over-action. The quiet, self-possessed teacher is rare. Over-action shows itself in loud voice, facial expression, hurry and movement, and irritability. Later, larval or undeveloped neurasthenia appears in many, first, perhaps, as hair-splitting, or undue magnification of trivial points, then as excessive tiredness, sleeplessness, loss of memory, ideas of incapacity and worn-outness, or as digestive troubles, palpitation of the heart, queer dizzy feelings about the head, or even headaches. These feelings may come on slowly towards the end of the session or term, and vanish with the holiday. They may also come suddenly, "one day when standing in front of the class," a cold, influenza, a little over-exertion, or trivial disappointment or accident, may determine the onset which years of varied anxiety has prepared and for which months of recovery may be necessary. It is no wonder that the teacher is tempted to seek spurious results in immediate effects in educational work. The full evidence of their work cannot be finally seen in school, it must be waited for; the crop of children leaving school will show it, better still those who have been a year or two in the throng and press of life.

Teachers who have had warning of nervous trouble must be content to go quietly and set all their activities on a lower plane. Pressure and strain are greatly increased, and efficiency probably hindered, by the piling up of administrative regulations to be continuously followed in the minutest detail. The demand for things, in themselves unobjectionable, may react by snowing under the chance of other good and interesting work. A reliance on human nature and much less mechanical supervision would enormously relieve the anxious strain on every one in school. Teachers should be liberally treated in genuine breakdown. The pay, and especially the pensions, often seem quite inadequate, and financial anxiety is one of the most considerable factors in neurasthenia as displayed when the doctor has gained the confidence of a sufferer.

There are subsidiary causes of troubles.

Voice failure is one of the earliest. Some pharyngitis and sore throat, with tired feelings or tenderness about the side of the larynx, are early symptoms, usually to be ascribed to improper voice production. This is generally caused by pitching the tones too high, and often arises from fatigue or where two classes are in one room, in the open air, or in a room with smoothly finished walls which echo. Hoarseness is common as a chronic sequel; it is occasionally due to the so-called "teachers' nodes," fibrous thickening on the vocal cord edges, which were common a few years ago. Actual loss of voice, which generally recovers with good health, occurs occasionally in neurotic and anæmic girls. In older teachers hoarseness may have a serious significance, and must never be neglected.

Teaching in an improperly lighted room, particularly facing a light, may be a cause of almost chronic ill-health; again, the strain of vision may produce recurring headache or other nervous trouble, even in people with remarkably acute distant vision. Every one after forty is the better for reading glasses, but any one over thirty is likely to gain from working glasses in relieving the nervous strain of accommodation if they have much paper work to do. The twitching of the lower lid sometimes felt, or *muscæ volitantes*, the floaters seen coming across the field of vision, are subjective effects showing want of tone and debility, generally relieved by a holiday.

Women teachers suffer much from digestive troubles, partly nervous, partly want of exercise, and helped on by tea-drinking to excess. They have also to be warned against constipation. In middle life the special danger of stimulants, taken first in tea as a rule, begins to appear; it is the beginning of the end. This is one occupation in which teetotalism is always to be recommended. Tobacco, apart from its evil effects on the heart and nervous system in the young, is worth a word of warning. By smoking more than three ounces a week, particularly of the darker varieties, loss of tone, debility, or slight illness may bring on a visual condition which neither good glasses nor improved lighting will remedy, and in which faces appear indistinct, brightly lighted objects confusing, and there is difficulty in distinguishing a new sixpence from a half-sovereign.

The teacher has many risks in this comparatively sheltered and regulated life and must learn how to save effort, avoid over-fatigue, and remain efficient. Specialization, as a rule, is a mistake from the point of view of nerve strain, if the particular subject is worked more than two hours a day. The fatigue coefficient of teaching is very great, and six hours' work a day is the most allowable; that being possibly an hour too much. Out of school there should be no schoolwork of any kind. The secondary school mistress is a constant offender against her own interests in this respect. Any professional work out of school hours should be in the way of recreation, as a hobby which is of interest, and never routine or drudgery.

The day-school teacher at work all day must avoid as a waste of nervous capital anything like evening teaching; neither "coaching" nor evening-school work is wise, even if well paid, for it has all to be repaid in exhaustion, with loss of health and mental vigour. A strenuous hobby to take him out of himself, quite apart from his professional work, whether it be beetles or Beethoven, is the best thing a teacher can possess. There is a trifling professional risk of infections of various kinds dealt with at the end of the chapter on infectious disease.

CHAPTER XIV

EYESIGHT IN SCHOOL LIFE

Affections of vision are among the most common hindrances to schoolwork, and as in many cases the result may be permanent defect in after-life, all concerned with education ought to have some knowledge of the structure and functions of the eyes.

The order to "sit up" is the one most often heard in school, and the reasons for its frequent repetition are worth inquiring into. In fact, the whole of schoolwork is influenced by and influences the vision of the child, and by grasping the general principles affecting the physiology of vision a teacher is not likely to go very far wrong in applying them in school practice; whereas even the most conscientious adherence to routine instructions frequently results in a mere caricature of the objects hoped for. For this reason the first part of this chapter will deal only with healthy eyes, and with the differences which occur normally, in some ways to the advantage, and in others to the disadvantage, of children as compared with adults.

The Physiology of Vision.—The actual affection of consciousness called vision depends on masses of nervous structures situated in the convolutions towards the back of the brain (the visual centres in the occipital lobes). The light rays acting on the nerve structures in the eyeball set up stimuli which are carried through the optic nerves to these visual centres, and there produce conscious vision. Vision may be greatly impaired (amblyopia) or even blindness result from brain disease without any noticeable defect in the eyes.

The Psychology of Vision.—The intelligent appreciation and interpretation of vision is a function of a higher order; probably carried out by a different part of the brain structure than that concerned in the reception of the impressions of sight. It is therefore possible to have perfectly clear vision but intellectual perception which is poor or entirely absent. This occurs physiologically, i.e. normally in the abstraction of deep thought, and it occurs in certain acute illnesses when the brain is affected by fever; but there are other cases where from some defect intellectual appreciation of a limited class of things may be defective or wanting. This condition shows itself best in connection with vision, in relation to such conventional signs as words, letters, or numbers. In such cases a person may be capable of dealing with numbers when expressed in Arabic numerals, or may be able to recognize and name every letter of the alphabet, and yet be quite unable to comprehend their simplest combination into words. Such "word-blindness" occurs not infrequently as a result of disease in the later years of life; and, although rare, it is occasionally seen in school children.

The higher intellectual visual centres being late in development, many young children present some degree of this condition. It manifests itself in inability to understand the spelling of the simplest words, and in rapidly forgetting again, so that the teacher says the child has no memory. This is a temporary condition for which time is the cure.

Another more general consideration is that whilst the lower and early developed visual centres reach their maturity comparatively early in school-life, the higher and comparatively late developed centres are only exercised by effort and with fatigue: they are most amenable to improvement by appropriate exercise, which should be the aim of education in later school-life.

The education by appeal to hand and eye, which is physiologically sound with young children and which in them involves effort and fatigue, becomes easy after a time, owing to the maturing and development of the lower centres. There is then risk of continuing to work these lower, now well-developed centres, easily and without fatigue, and failing to develop the intellectual areas which can only be worked by effort. Work in the later years of school-life which appeals to hand and eye chiefly, and does not involve determined reasoning and intellectual exercise of an original kind, is to a great extent vain repetition, and may be regarded as educationally almost wasted time.

In great contrast to the "mind-blindness" due to want of development is the extraordinary capacity of the lower centres in the same young brains to store away during infancy all kinds of memories. Inattentively and unconsciously the eye receives picture after picture, and probably without any real analysis of their worth stores away their memories in the brain. Each impression so retained has a permanent influence on every future nervous action. The storing of these memories is scarcely voluntary. It is more of the nature of a passive impress, and the character being to a great extent built out of the sum of all such memories, character formation is probably going on faster in the infant department than at any other time in life. The child at this time is almost the victim of its surroundings. In the infant school the cleanliness, brightness and colour of the schoolroom, the wholesomeness of the other children, the neatness of dress (*simplex munditiis*) and sweetness in manner and voice of the teacher may have a more permanent influence than anything she endeavours to teach.

The Physics of Vision.—In order to see any object it is necessary that an optical image of it should be formed on the nerve structures in the eye.

For the formation of an optical image the rays of light require to converge to the image. Naturally, however, rays from an object diverge, or if the object be very distant they diverge so slightly that they may be regarded as parallel. These diverging or parallel rays must be rendered convergent, which can be done by passing them through a convex lens, and if a certain choice is made as to form and material a lens can be obtained which will form a clear image of distant objects at 22·5 millimetres behind its front surface (25 millimetres = 1 inch).

Structure of the Eye.—The structures of the normally developed eye constitute an optical equivalent for such a lens. The form of the globe of the eye is chiefly due to its firm external coat of dense fibrous structure, called the *sclerotic*, which shows as the white of the eye. This coat makes up the chief thickness of the wall of the eyeball, except behind, where it is perforated by the optic nerve, and in front over about one-sixth of the surface, where it is replaced by the thick horny but transparent *cornea*.

Over the inner surface of the sclerotic is spread a thick mass of blood-vessels constituting the *choroid* coat; this is covered on its inner aspect by a layer of dense black pigment, preventing reflection of light in the interior of the eyeball. Supported by the choroid and lining the interior two-thirds of the eyeball is the fine transparent nervous sheet called the *retina*. This is of great complexity of structure, and is really an outgrowth from the brain, and in the developing chick it can be traced from the time it is part of the brain wall till it is the retina in the eye, and still connected with the brain by means of the optic nerve. About two-thirds of the distance forwards from back to front the retina loses its complicated structure and is continued as a single layer of thin membrane which, with the choroid, is gathered into a thick mass of tissue surrounding the interior like a collar, and called the *ciliary body.* In front of this again the retina and choroid are continued as the thin contractile diaphragm known as the *iris.*

Suspended in the opening in the collar of tissue which forms the ciliary body is the *crystalline lens,* a structure formed of clear layers of prismatic fibres arranged to form

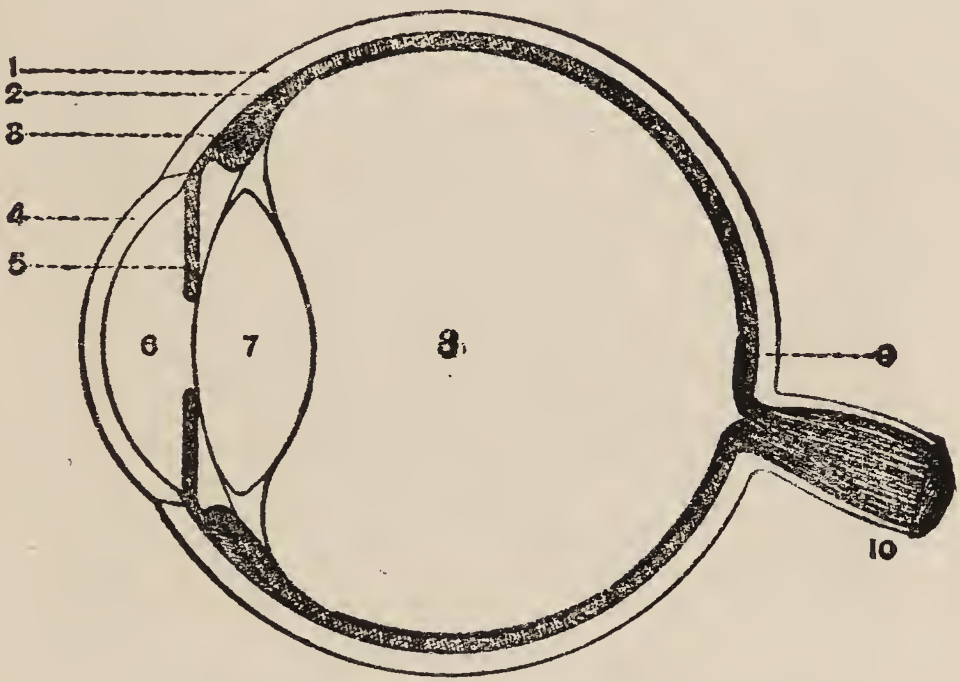


FIG. 16.—Vertical section of the eyeball.

1, Sclerotic; 2, choroid; 3, ciliary body; 4, cornea; 5, iris; 6, aqueous humour; 7, lens; 8, vitreous humour; 9, retina; 10, optic nerve.

a very elastic lenticular (double convex) body. The lens is contained in a thin capsule which is slung by a number of fine fibrils passing from its margin to the nearest projections of the ciliary body. In the space in front of the lens, between it and the cornea, is the *anterior chamber,* filled with the clear aqueous humour. The rest of the globe behind the lens is filled by an equally clear gelatinous *vitreous humour,* or vitreous body; this is partly surrounded by the retina, and in front by the ciliary body and lens.

In the normal eye at rest the light from distant objects falls as parallel rays on the cornea, which causes them to converge slightly; in passing the iris the more peripheral rays of light are cut off, a central beam of light falling on the lens; this powerfully refracts the rays, bending them towards the axis, so that a clearly focused optical image falls on the centre of the retina, which lies 22·5 millimetres behind the cornea. The numberless impressions produced by the rays of varying colours and intensities in the different parts of the image cause differing nervous actions,

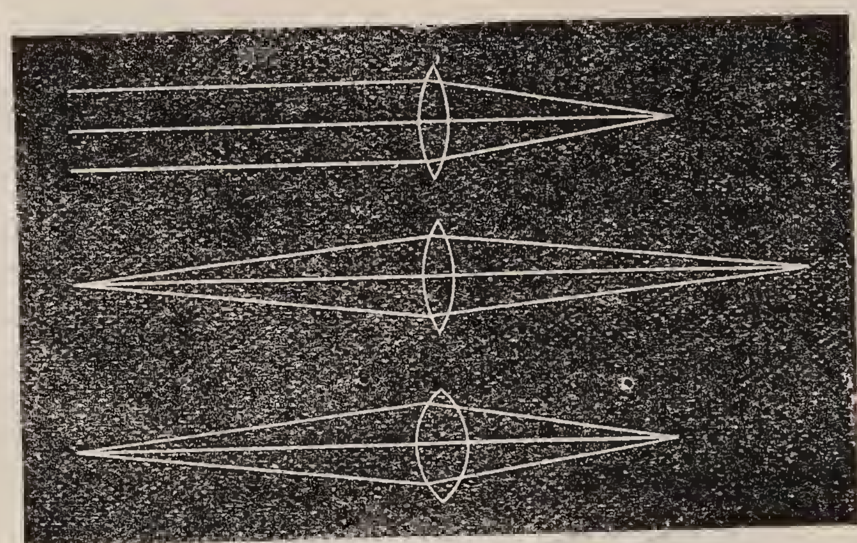


FIG. 17.—Diagram showing effect of a biconvex lens on rays of light.

1, Focus of parallel rays; 2, focus of divergent rays; 3, focus of divergent rays brought nearer by more convex lens.

which result in innumerable separate stimuli travelling along the fibres of the optic nerves to set up conscious vision.

A lens has been spoken of, of such form that rays from distant objects are clearly focused in an image 22·5 millimetres behind the front surface. This corresponds in optical action to the eye, which focuses distant objects on the retina. The lens of the eye bends light rays to a fixed amount, and will therefore bend the diverging rays from an object which is not very distant, so that they focus farther behind it than the 22·5 millimetres (as in 2, Fig. 17). In order to have the image formed at this required distance, more bending power is required, which can only be obtained by interposing an auxiliary lens, which will be able to convert the diverging rays to parallel before they fall on the original lens. In the case of rays from an object 1 metre distant, the auxiliary lens would have to be such that it could focus parallel rays at a distance of 1 metre. This is about one-fortieth of the effect of the original lens. In the case of an object half a metre away the auxiliary lens would have to be such that the parallel rays would be focused at a half metre or one-twentieth the power of the original lens, and so on.* For every alteration in the distance of the object there has to be an alteration in the power of the auxiliary lens if the image has to remain at a fixed distance, as it does in the eye.

In the case of the eye this alteration, equivalent to the interposition of auxiliary lenses, is effected by a change in the shape of the lens, whereby it is enabled to focus objects from a distance or from within a few inches of the eye, each change in the distance of the object so focused involving a corresponding change in the lens of the eye (Fig. 17).

The functions of the eye which may be mentioned are:—

1. Adaptation.
2. Accommodation (or focusing).
3. Convergence (or centring).

The **adaptation of the eye** embraces several functions too complicated to detail here. They are chiefly pro-

* In ophthalmic practice a lens which would focus parallel rays to 1 metre is said to have a refractive strength of 1 diopter. A lens focusing parallel rays to half a metre is double this power and referred to as a lens of 2 diopters, and so in proportion, a lens of 20 centimetres focus being 5 diopters.

tective. The iris is retracted in a dull light so that the pupil is widely opened and admits as much light as possible. In bright light the pupil may be pin-point in size. In certain nervous or debilitated conditions it is also frequently found much dilated. As a rule, on looking at a distance the pupil is somewhat dilated, and for near objects contracted.

The power of detecting differences of light and shade improves after resting the eye from a quarter to half an hour in the dark. It is this that in the narrowest sense constitutes adaptation.

The great functions of importance in schoolwork are those of accommodation, performed by internal muscles in the eyeball, and convergence, performed by the external muscles.

Accommodation.—When the eye is at rest and the gaze is fixed on a near object, a distinct effort is felt which corresponds to a certain alteration in the eye. This effort and the changes effected by it are known as accommodation.

The lens at birth is much larger relatively, exceedingly elastic, and more hemispherical than in after-life. The structures of the eyeball grow at differing rates, the result being that the small suspensory fibrils which connect the edge of the capsule of the lens with the nearest parts of the ciliary body are habitually tense, and put tension on the inextensible lens capsule, thus causing the lens to be compressed and flattened. By the contraction of certain small muscular bundles arranged partly circularly and partly radially, it is possible for the opening in the ciliary body, against which the lens is slung, to be narrowed, the tissues being drawn a little forward and in, so that the pull of the suspensory fibrils is lessened. When this occurs the tension of the lens capsule relaxes and its compressing effect on the lens diminishes. The elasticity of the lens now comes into play and it tends to resume its earlier form, becoming thicker and more convex.

In this way the crystalline lens becomes capable of bending the diverging rays from near objects to such an extent that, as illustrated in Fig. 17, they meet in focus at the same position as did parallel rays from a distance when the eye was at rest and no accommodation exerted.

It is obvious also that the accommodation depends not entirely on the muscular contraction, but also on the elastic properties of the lens which help it to resume its original thicker and more spherical state when the pressure of the capsule is relaxed. If the elasticity of the lens is diminished beyond a certain point, however much the muscles are contracted and the tension of the capsule relaxed, accommodation may fail. From birth the elasticity of the lens steadily lessens, so that the amount of possible accommodation diminishes with age. It is greatest in the young child. When the age of forty is reached it has usually decreased so much that accommodation for objects nearer than about 25 centimetres (10 inches) cannot be satisfactorily maintained, and reading within the ordinary distance becomes difficult.

The amount of accommodation required increases rapidly with the nearness of the object, and consequently the muscular effort required to accommodate is also increased. The alteration in refraction of the eye in changing from the position of rest (distant vision) to the condition required to see clearly an object 1 metre (say 40 inches) distant being taken as a standard, then the change required to see an object at half a metre is twice and at a quarter metre four times as great, so that with every increment of distance by which the object comes nearer the eye there is a very much greater increase in the accommodation required to see it clearly.

The diagram (Fig. 18) represents this relation, and shows that when within a quarter metre (10 inches) from the eye, the increase of accommodation represented by the vertical lines takes place so rapidly that every inch nearer means a disproportionately greater strain on the ciliary muscles.

These statements are based on the proportions of the fully grown and normal eye, which has an axial length of 22 to 23 millimetres.

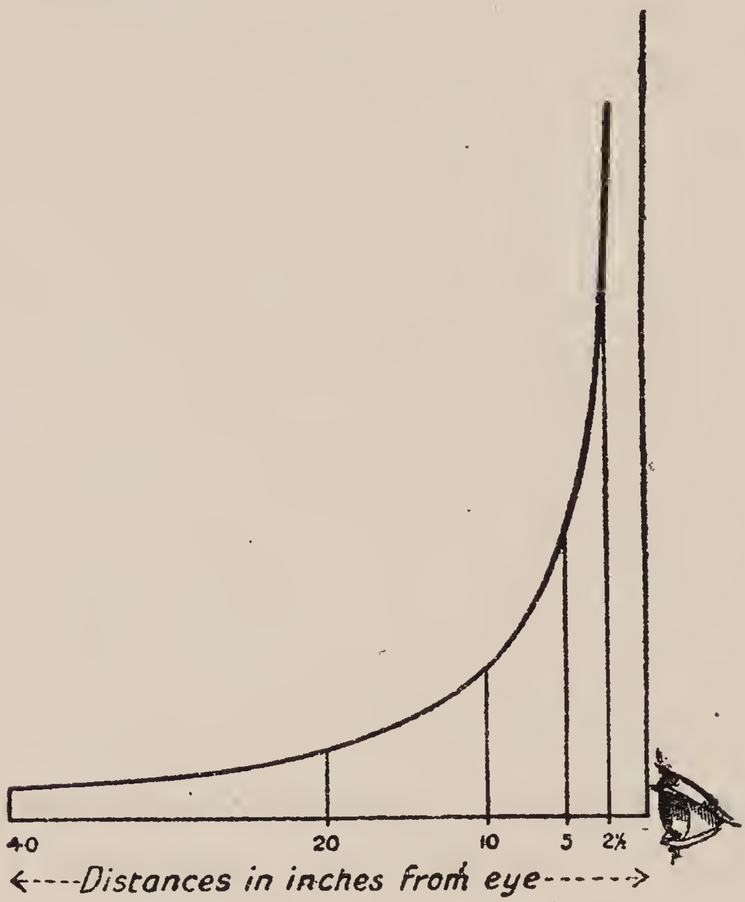


Fig. 18.—Diagram illustrating increasing amount of accommodation required with increasing nearness of object.

The Young *v.* the Adult Eye.—If the natural history of the eye be studied, development will be seen to take place from a flattened mass of tissues, which in growth gradually tends to become the nearly spherical eyeball. In the new-born child the eyeball is relatively short antero-posteriorly, with a shorter optical axis than in the adult, and all through childhood this condition, becoming less with age, may be taken as a normal condition for the eye. In such a relatively shortened eye parallel rays from distant objects will not be clearly focused on the retina, but are directed to a focus behind it. To get a clear image the lens has to be accommodated so that it bends the rays to a focus on the retina. The developed adult eye sees distant objects without effort when it is in its condition of rest; the child has to compensate by accommodation for the shortness of its eye, and the amount of compensation required is greater the younger the child; so that normally children only see distant objects clearly by using an effort of accommodation, and to see near things they have this effort to make over and above the effort which an adult makes to compensate for the nearness of the object. This is one of the disadvantages from which children suffer.

The minute ciliary muscles are almost ceaselessly in action, and this involves considerable nervous strain if they are worked up to their full possibilities. These possibilities are greatly diminished in older people; but in young children, owing to the elasticity of the lens, there is always considerable risk of overworking the accommodation, leading to fatigue and ultimately to general nerve strain.

Physiological Law of Work.—Immature and developing nerve cells are particularly liable to exhaustion by continuous work. The natural method of education is for the average work done to be comparatively slight, with at infrequent intervals very great demands for an exceedingly short time. Under such natural conditions an infant would employ its vision chiefly on distant things, and occasionally for an exceedingly short time on near objects. The conditions of school-life practically reverse this.

Young children set to continuous work with small objects are not equal to maintaining the strain of accommodation, which, as we have seen, has in their case not only to compensate for the nearness of the object, but also for the comparative shortness of the optic axes of their eyes.

If the attempt to maintain clear vision by muscular effort be given up, some improvement in the impression can be gained by bringing the object nearer the eye. The larger image thus produced, being somewhat out of focus, is confused to an extent depending inversely on the distance; but at the same time the gain in size of the image formed on the retina means a greater impress on the nerve endings, and consequently a more voluminous nervous stimulus sent up to the visual centres in the brain, so that whilst learning bad visual habits the child yet gains temporarily.

In working continuously with small objects, pupils in the lower school tend to hold their work from 4 to 6 inches from the eye. It ought to be kept at least 10 inches off, and the chief problem of hygiene in teaching methods is how to effect this necessary working distance. The instruction that infants "should not stoop over their work nor should they bring it nearer the eyes than 10–12 inches," appears to have left out of consideration the fact that with infant length of arms this is impossible.

So far the focusing of the lens to accommodate for distance has alone been discussed, but, as in all optical apparatus, the centring has to be attended to, the best image being that formed in the optic axis.

Physiology of Vision, *continued.*—The human retina is almost peculiar in that, at one small spot, exactly in the optic axis, the sensibility of the retina is enormously heightened. This is known as the yellow spot, or *macula lutea.* The visual sensibility over the rest of the retina is so slight that it would not suffice for the reading of ordinary newspaper type. This can be shown by the experiment of covering one eye, and then steadily fixing the gaze of the other eye on a dot on a newspaper held up at a distance of 10 inches; if the eye is kept fixed, it is noticed that only the letters over a small area surrounding this fixation point can be distinguished. This area of the newspaper type, which could be covered by a shilling, corresponds to the part of the image falling on the macula. The great difficulty in this experiment is to keep the eye still, for the centring mechanisms are so perfect that any attempt to distinguish a letter causes almost unconscious adjustment of the eye to fix the letter, that is, to centre the eye so that the image of the letter falls on the macula.

Further, another almost exclusively human peculiarity is that the two eyes are adjusted in the orbits so that they look forwards in their position of rest with the optic axes parallel. In most animals the eyes look outwards at an angle, in some in such opposite directions that they have quite different fields of vision, but in the human being the fields of vision of each eye overlap to a great extent, and the eyes are adjusted so that the axes intersect in the object looked at.

The eyeball is placed in each orbit and maintained in position, in a loose mass of soft fatty tissues, by six small muscles, two of which (the oblique muscles) act as auxiliary to the others, and also in helping to steady the globe in rotation. For school purposes the oblique muscles may be neglected.

There then remain the four straight muscles of each eye (internal, external, superior, and inferior recti), which cause the eye to turn about its centre of rotation, so that the cornea moves in, out, up, down, or in any resultant direction compounded from these movements.

If, for example, the external muscle of the right eye and the internal of the left are thrown into action, the eyes are rotated to the right and the corneæ are noticed to move in that direction.

The centres controlling movements of the eyes lie far forwards in the brain, being nearest to the large silent area of the frontal lobes, which are generally supposed to be associated with complex intellectual processes. The highest intellectual functions involve a concentrated mental action which is generally associated with some slight stimulation of the neighbouring areas of the brain, in that the eyes, for instance, are fixed into a motionless gaze; the integrity of the parts effecting such concentration can be presumed if the control of the eye centres is elicited, as a rough test, by directing a child to fix its gaze on a small object held up a yard or so off. A child which cannot definitely fix and maintain its gaze when directed to do so may be judged to be wanting to some extent in intellectual qualities.

On the other hand, children who are backward from want of development, caused either by disease or by lack of education, as Warner has pointed out, often show lack of power in the voluntary movements which should be effected by the eye muscles. If told to watch the movement of a finger or pencil held up before them and moved from right to left, and *vice versa*, they rotate the head instead of rotating the eyes. This is a rough but useful test for feeble-mindedness in children.

If the gaze be fixed on a distant point the eyes are said to be in the position of rest, with the axes parallel. To fix the gaze on a nearer object both internal recti muscles are contracted, rotating the globes inwards till the optic axes intersect in the object looked at. This action is termed convergence.

Convergence or Centring.—The convergence is effected by the contraction of the internal recti muscles, and the amount of muscular contraction required to maintain this convergence increases with the nearness of the object. Whether by long continued association and inheritance a linking of accommodation and convergence has come about cannot be discussed here, but there is an intimate connection in the nervous mechanism of the two functions, so that when the eyes are converged to a certain distance, accommodation is also effected for that distance, and any considerable deviation from this relationship can only be obtained and maintained by a considerable nervous strain.

Nervous Strain from Use of the Eye Muscles.—The continued overuse of one of these muscles, or of one set of muscles, is a most frequent cause of headaches, pain, and general nervous disturbances. Apart from cases where a slight weakness of one muscle causes over-action and pain or neuralgia, as in cases where a tendency to squint is habitually corrected (*latent squint*), severe pain may result, more especially in older children or adults, from mere overuse of the eyes, as is common in young pupil teachers and students with quite normal eyes, from overuse of the muscles of convergence, or in many people from continual use of one set of muscles, e.g. one external and the other internal rectus, in looking out of the carriage window in railway travelling.

The "academy headache," from continuous exertion in raising the eyes, is notorious, and in another way is not uncommon in the physically powerful cyclist who with back horizontal keeps looking ahead, straining the superior recti muscles of the eyes and inducing headache even with normal, i.e. distant, sight.

Headaches, unless due to astigmatism, are distinctly rare in school children below the age of ten. The cause is most commonly found in the naso-pharynx.

In the case of the child with short ocular axes excessive accommodation is needed to compensate for the shortness of the eyes, and if the corresponding amount of convergence is exerted there is an excess of convergence over what is necessary; this means that the eyes are turned in too much, and as one eye is possibly a little better either in function or relative position than the other, the object is "fixed," that is, looked at by the best eye, the other being inturned to an excessive amount, constituting inward squint. This is a common condition, which may be the result of engaging the child in fine near work, or may merely be the result of some debility, temporary or otherwise, affecting its capacity to maintain the strain necessary to make up for the difference between convergence and accommodation. If there is great defect in the development of the eye, or other defect in vision, the squint, which in such cases usually starts before school age, may be permanent, but in the majority of cases, either with the re-establishment of health or with natural growth, it passes off.

Visual Acuity.—The exceedingly acute vision attained by a small part of the retina in the optic axis, at the part known as the *macula lutea*, or yellow spot, has been spoken of. There is a possibility that although the anatomical structure is there at birth, the functional development of this visual acuity may be comparatively late, infants not seeing quite as well as they ultimately will, because the nerve structures of the eye are still immature. A great improvement in visual acuity is generally assumed as occurring between the sixth and seventh birthdays, but this is explained by insufficient precautions in testing. With sufficient care the vision of six-year-old children is found more acute than subsequently. Testing of visual acuity is described on p. 165.

Eye Work in Infant Schools.—The functions of the eyes and their development in early years of school-life have now been traced. From consideration of these it is evident that in the infant department the greatest consideration must be paid to eye work. The infant cannot see so well because—

1. In a considerable proportion the actual nervous mechanism is not fully matured to give or interpret the full value of the image on the retina.

2. The accommodative and convergent strain cannot be maintained for long.

3. There is required an excess of accommodation to compensate for the shorter eyeball.

The indications from these conclusions are (*a*) to exclude very fine work from infant schools, and (*b*) to insist on work only at a minimum of 10 inches distance from the eyes; otherwise a school habit of near working distance is acquired, which to a great extent persists through school-life, and is the cause of most of the hygienic troubles of the scholar.

Next to the better ventilation required in most schools, the prevention of the formation of the bad habit of holding objects at a less distance than 10 inches is the most important hygienic improvement needed.

Much work is done in school involving the continued working of nerve centres already trained, or getting results in which errors are made less apparent by being made less noticeable, or other work having a deceptive appearance of accuracy which may be grouped as "spurious result" work.

All fine sewing is to be condemned as uneducational. Map-drawing with crow-quill pens and fine name-printing are equally bad; drawing by young children in small squared copybooks or on squared slates is likewise wasteful educationally. Ordinary children like this kind of work because it involves no mental effort, being mainly repetition without intellectual effort.

The younger children who are allowed such work, or even drawing with pen or pencil, learn the bad habit of working near their eyes, and this is also helped by the method of reading as frequently taught the younger children with primers.

It is to be noted that many mentally unsteady individuals of what are known as the "higher degenerate" types do this mechanical work, which gives results without mental efforts, well.

Reading and Writing in Infant Schools.—Reading and writing should be learned, letters first, then their groupings into simple words, from symbols not less than 6 inches long, until the child is quite familiar with them. This work in the case of reading should be entirely distant by means of blackboard or reading-frames, a very large print

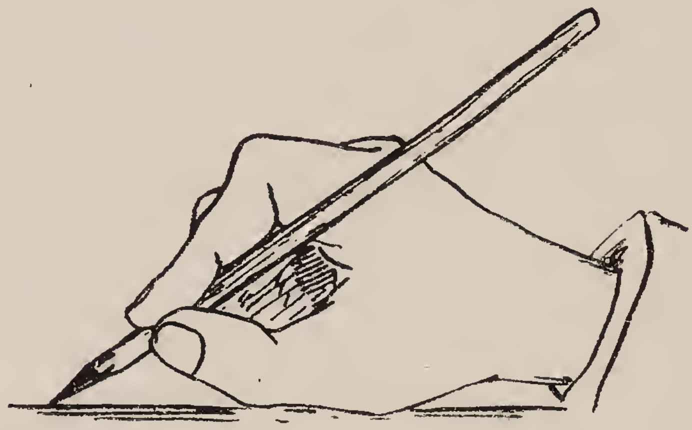


Fig. 19.—Infant writing.

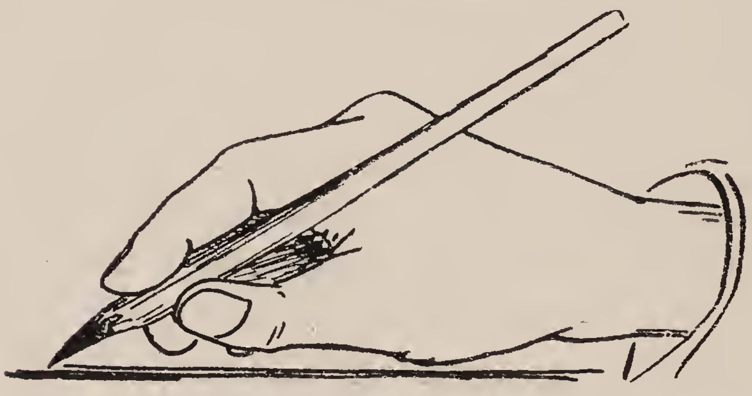


Fig. 20.—Adult writing.

primer being occasionally allowed in the highest class of the infant school to add interest to the lesson.

Writing begins also by the child gaining familiarity with the letter forms by coarse methods, as chalk-drawing on the blackboard. Every child in a six-year-old class ought to be able to come at once from its place, take a piece of chalk, and print its name in letters six inches long on the blackboard. Unfortunately, few can do so. Sand trays, pieces of string, or thick malleable wire to bend into shape, shells to lay down, or pieces of stick, are all useful adjuncts to teaching the conventional signs to very young children.

Such children should have free-arm work, being made to stand well back from the board, and should be set to draw things as they see them from the first.

It cannot be too strongly insisted that *needles, pens, pencils, and paper are all out of place in the infant school*, that they cause overpressure and aid the development of bad school habits, only got rid of by much re-education in the upper departments; for instance, an infant learning to write with pen or pencil, in its efforts to concentrate muscle work, invariably bends the forefinger, so that there is an acute angle in it. No infant scholar will learn to hold a pen in any other way, for the physiological reason that it is the easiest for him. Inasmuch, however, as it throws all the work on a few fine muscles, it is a bad method for general use, and therefore has to be unlearned in Standards I or II.

Cinematographs.—Cinematographs have become a popular form of mental dissipation among children. They afford excitement and the thrill which broadens their emotional life, besides imparting a good deal of experience of a passive kind which is a substitute for the much healthier nervous functioning of play. The instruction conveyed by the cinema in the average show is not what the child goes for, and may properly be neglected. The excessive emotional stimulation rapidly exhausts the child, and premature acquaintance with various aspects of life before the power of judgment of what is to be accepted and what rejected must be harmful to its orientation later as a citizen; further, the mere repetition tends to a *blasé* condition and a stunting of the emotional life later, so that they are likely to be passive and unresponsive to duty. The other objection, apart from late hours and the foul atmosphere, is eye strain. The child is usually in cheap seats in front, and the screen is much greater than the field of vision; it is also generally raised, so that the centre of the picture is perhaps 30 degrees above the horizon; under these conditions, with the short eyeball of the child, eye strain is excessive and headache common from mere overwork of the external ocular muscles. It is absurd to have costly arrangements in school and to prohibit teachers' platforms in classrooms, and yet allow children to attend such shows freely. No child under fourteen should be allowed in any cinema after seven in the evening, nor should it be allowed to sit within 15 feet of the screen, or to see a film which has not been especially approved for children.

School Lighting.—This is dealt with in a later chapter on p. 316. Children suffer, apart from want of light, from too rapid changes. The flickering of a gas-jet may be painful, the sunshine in a classroom may be a real nuisance owing to the eye being adapted for a certain average illumination. The eye in the evening may find a desk surface too bright to read on when illumined by seven candle-power, but in the daytime a play-shed outside may be "too dark to see in" with two or three times that amount of light. Confusing shadows may interfere with the work. A room lighted about equally from right and left throws annoying shadows from the pen-point. On the other hand, want of shadow may be a trouble; any fine work with textures becomes difficult with indirect lighting, which is nearly shadowless. **Glare** may be the cause of difficulties. Primary glare from too bright light producing actual pathological change, as, for instance, from looking directly at a solar eclipse, is fortunately rare, but secondary glare, producing annoyance, from surfaces of comparatively low intensity, surfaces of paper, walls or desks, the setting sun, or from beams of nearly horizontal light from ribbed or badly set prism glass, is due to the retina being adapted for an intensity of light representing a general average, whereas these small glare spots are of much higher intensity. There are other contributing causes of glare, but the importance of the whole subject is as yet hardly appreciated. Glare from the surface of steam-pressed paper, which should never be used in schools, is of the nature of regular specular reflection, and is therefore worst when facing a window or source of light. It is measured by the ratio of regularly reflected light to that irregularly diffused, and is considerably diminished in indirect or diffused lighting, or by bringing the paper nearer the source of light, when the glaring rays remain of a constant brightness, whilst the brightness of the ordinary non-glaring light increases.

For the teachers' use, blackboards with white and coloured chalks are the most convenient. The colours of the chalk should be selected for visibility, some blues and yellows being poorly seen against the board or in artificial light. With a large blackboard and white chalk there is perhaps better recognition of the letters than there would be with black letters on white. The pupil of the eye is probably wider, and in a short time the eye more sensitive, so that the white chalk has real advantages.

Irradiation has also a part in making the white letters appear larger and clearer. In artificial lighting there should be an average of 60 per cent. more light on the blackboard than on the desks.

Where children are drawing at desks with chalk, wooden blackened boards are the best, but blackened cardboard is frequently used on account of cheapness. In rubbing out, it is best to use very small dusters or solid rubbers, to avoid scattering dust.

Type of Books.—With English type the only troubles likely to arise are from fine type, from the lines being too long, and insufficiently leaded, and from the paper being finished with a glossy surface. The *type* should be clear and large, and the construction of such letters as *h* and *b*, *v* and *n* should be especially precise.

The following words represent well-known sizes of type:—

Double Pica.	*Great Primer.*	*Pica.*
No type	smaller than	Pica should

Small Pica.	*Bourgeois.*	*Minion.*	*Pearl.*	*Brilliant.*
be used	while	teaching	children	to read

The British Association Committee have published a very satisfactory report on the sizes of type, which, however, rather over-elaborates the needs of the situation as regards schoolbooks.

Type is measured in English or American measure by points, of which 72 go to an inch. This determines the body of the type, which is much larger than a small letter such as *m*, as provision has to be made on it for either up or down strokes of the long letters. The *face* of the letters on the type, on which the size of the printed letter depends, is not necessarily fixed by settling on type of so many points. Clean-cut, well defined type, without fine hair-strokes, should be used; condensed or compressed type is to be avoided, breadth being more important than height; too heavy thick strokes, again, would diminish visibility.

In any specification to fix the sizes of print in books the simplest items can be got by taking a limiting height for the small letter; the width for such a letter as *n* should be equal to the height. There ought to be a clear interspace between the lines of double the height. The minima for school use could be conveniently stated as, for infants up to seven years old, 24-point type, the minimum height of the small letter, 2·8 millimetres; for children reading by words, and aged seven to nine, 14-point type, with letters of at least 2·25 millimetres height; with older children reading fluently, 11-point type, the letters not less than 1·5 millimetres high, will secure safe results for vision. The length of line should never exceed 4 inches. The recommendation, known as Cohn's test, that through a square hole of 1 centimetre side cut in a card, not more than two lines should be visible when it is laid on the print, is a safe limit for schoolbooks. This has been amplified by Russian regulations, that under this test not more than fifteen letters should be visible at once in the square centimetre space.

Illustrations should be simplified for the youngest children; without great detail and in outline portraying action without overlapping figures. Small scattered marginal pictures are not useful; even for the older children line drawings are preferable, and only for natural scenery should half-tone blocks be used. Insets on highly glazed paper, if needed, must be sewn in, not pasted. Letterpress in coloured letters is to be condemned. The spacing between the words is not a serious matter; if crowded, learners make more mistakes in reading; whilst with widely leaded lines they make mistakes in beginning the correct line.

Gothic type, the German type, is always to be condemned. Its abolition in Sweden has been followed by the happiest results in a great decrease in school myopia. For daily life it should be abolished everywhere.

Practically all books are printed on white or yellow toned papers, giving good contrast. Tinted papers with neutral tints spoiling the contrast are bad. Writing ink is often very bad. When supplied in powder form the mixing is sometimes done badly at school. Fluid ink should be supplied to schools, and it should never be watered. Pale ink, or ink which turns black after a time, should be abolished from school.

It is important that neither writing nor reading should be permitted in the dim light of evening.

The letters on many maps in schools are most trying to the eyes, the lettering not only being fine, but the maps having often been printed from old and worn plates. Maps should contain as few data as possible, teaching by wall-maps and outline-maps being preferable.

Desks and Seats.—Desks and seats are described in Chapter VII, p. 328. The most carefully adapted single seats and desks will, however, have their potential value diminished when used by a class that has already learned the near working habit.

Habit Spasm of Eyes.—In many cases where a fine muscle is habitually overtaxed a condition of nervous irritability and want of control is set up in the nerve centres, resulting in what are termed "functional paralyses" or "habit spasms," from the mixture of spasmodic action and almost paralytic weakness displayed. Telegraphist's cramp, pianoforte player's cramp, writer's cramp are well-known examples of such occupation diseases. The occupation disease of the scholar may be said to be spasm of the eye accommodation. The eyes habitually used at too close a distance at last have the nervous mechanism of the ciliary muscle thrown into such a state of irritability that on attempting to fix the gaze on a distant object the habitual contraction of the ciliary muscle comes into play and the eye is accommodated to its usual near use. Although the eye may be quite normal as regards its dimensions, yet from the long sustained near work, and the accommodation having got adapted to this, it cannot be relaxed sufficiently for distant vision, so that the scholar sees distant objects badly and appears to be shortsighted, seeing near things well. Associated with this condition there is often some congestion and irritability of the eye set up which draws attention to it, and the fact of distant vision being bad often accentuates the child's complaints.

Temporary suffering from this condition is common, especially in finely textured children of the nervous type, and most often in girls over eleven years of age. Such children are sometimes taken to sight-testing establishments presided over by the "certificated optician," who generally in such cases prescribes weak concave glasses. These improve the distant vision for a time, but ultimately aggravate the condition, until in bad cases work continued for more than a few minutes may be impossible. From such cases also permanent shortsightedness often develops.

Tests of Vision.—For testing children's vision a series of graduated letters on a test card is used. In the cards in general use (Snellen's Test Types) the top letter should be read at 60 metres (it is marked, in small outlined letters, D = 60). The second row, 36 metres; third, 24; fourth, 18; fifth, 12; sixth, 9; and seventh, 6. The child to be tested stands 20 feet (= 6 metres) in front of the card, which is hung in a good light. He ought to be able to read all the letters correctly with either eye, such a result being recorded as $V = \frac{6}{6}$—the numerator expressing the distance in metres at which the child stands, and the denominator the distance at which the smallest letter distinguished ought to be read. If with the right eye the child had only read the first three lines, it would have been recorded R. $V = \frac{6}{24}$. Any fraction less than unity denoting defective visual acuity.

In testing a long series of children it is found that girls present a greater percentage with defect than boys, and younger children than older children up to the age of eleven, when the conditions are reversed. It is found that country children attain their maximum visual acuity, as a rule, much sooner than town children. On the other hand, if all the children in a certain standard only be taken, the younger the child in its standard the greater its visual acuity as a rule.

Statistics of Eyesight of School Children.—So far vision in ordinary school children only has been dealt with, and the strain which improperly applied tasks throw on them has been pointed out. It seems almost strange that in spite of all these imposed strains the majority come through school-life with their vision not a bit the worse, save that possibly their finer visual judgments as regards distance and distant objects have been allowed to remain undeveloped. There remain a considerable proportion who from some inherent weakness, whether nutritional, structural, or nervous, are unable to pass the strain of continual eye work unscathed, or who have suffered by the scars and marks of disease. What these numbers are it is difficult to say; but taking the best group, boys between the age of ten and twelve, it may be taken that 10 per cent. fall short of normal vision. Other groups exceed this, so that Mr. Brudenell Carter some years ago, from examination of several thousand London children, stated that at least two-thirds of the eyes tested fell short of normal.

There is reason to suppose that the personal equation of the child obtruded itself in these statistics, and that the group was largely made up of young children. Statistics regarding school children in the mass, whether applied to vision or any other personal condition, are worth little for comparison unless arranged in groups according to age and sex.

In the Bradford Board Schools, 39,118 children were examined as to their acuteness of vision, by means of test cards containing standard letters, each scholar filling in on a piece of paper all the letters on the card which he could distinguish clearly. The results are shown in Fig. 21. As the number of children in each standard varied from 503 in the Ex. VII and 2,194 in the first to 7,553 in the third standard, the basis of facts on which the percentages of defective vision are framed is sufficiently large to be trustworthy:—

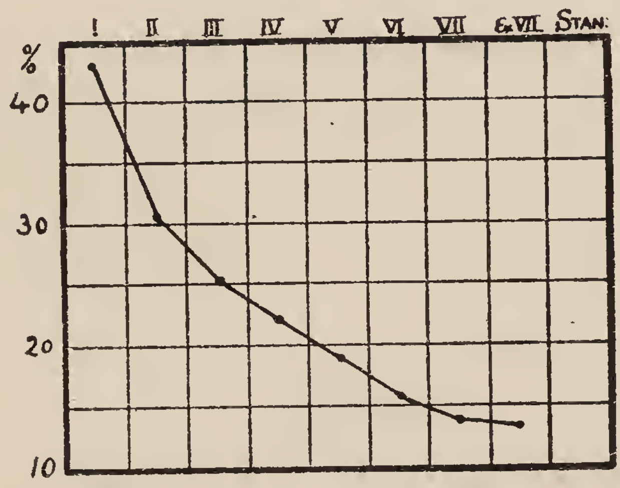


FIG. 21.—Percentage in each standard with defective visual acuity. 39,118 children in standards. (Bradford School Board.)

In another set of observations in which 7,755 girls and 7,787 boys were examined, and classified according to age, the results shown in Fig. 22 were obtained:—

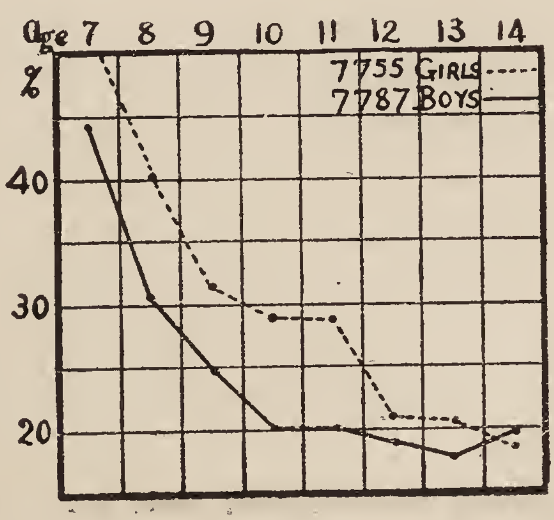


FIG. 22.—Percentage with defective visual acuity at various ages.

Later and more detailed examinations have shown that in the elementary schools of English towns—

(1) The percentage with normal vision increases at every year of age and standard, till in the highest classes it is over 80 per cent.

(2) About 10 per cent. have vision as bad as V.A. = $\frac{6}{18}$. This remains constant through school-life. The greater part of the defective vision is due to slight defect which gives fair but imperfect vision, due probably to both ocular and mental conditions, and of the greatest importance educationally in the first half of school life. Very bad visual acuity (V.A. = $\frac{6}{36}$ or worse), due to accident or disease and probably also to spasm and myopia, is met in a small proportion, increasing from about 1·5 in Standard I to about 3·5 in Standard VII.

Treatment of Sore Eyes.—Defective children in regard to vision comprise a considerable number who have suffered damage from inflammation of the cornea. Many children of low resisting power are prone to slight inflammatory attacks; the children who from any cause strain the eye are more liable than others, the eyes feel burning and hot at times, there is a little "matter" in the corner, they may be bloodshot in the mornings, or the lids may be stuck together on waking by dried exudation; and the little crusts which this forms at the roots of the eyelashes cause irritation, and chronically inflamed thickened edges ultimately develop on the lids, an inflammatory condition called *blepharitis*. It is chiefly seen in unhealthy children, who require much fresh air and cod-liver oil, but also in healthy children, who being longer-sighted than usual have the eyes irritated and congested by constant strain.

For these chronic conditions, and for almost all slight inflammatory conditions about the eyes, a useful treatment is to bathe the eyes well with a lotion composed of as much powdered boracic acid as will lie on a penny, dissolved in a pint of tepid water; and at bedtime the lower lid should be pulled down and a piece of ointment the size of a split pea laid on its inner surface to dissolve during the night.

On the advice cards formerly given for vision in schools under the School Board for London there was the following:—

"You are cautioned against the grave risks children may incur by wearing glasses as prescribed by the various sight-testing establishments, certified opticians, chemists, toyshops, or any other than qualified medical men.

"In most cases of pustular eye inflammation, irritable or sore eyelids in delicate children, a piece of the following ointment, the size of a lentil, in each eye at bedtime will be found of benefit. Any chemist will supply it, of the following composition: Powdered yellow oxide of mercury, 3 grains; lanolin, 2 drams; vaseline to half an ounce."

The above treatment may only give temporary relief if there is eye strain, and the use of proper glasses may be necessary if permanent relief is to be obtained.

Formerly much bad eyesight was due to the results of small-pox. The practice of vaccination has materially diminished this, and now serious eye defects are chiefly due to disease in the new-born infant, from want of proper supervision during the first week of life, or later in life from haziness of the cornea caused by inherited constitutional disease. Mere colds and catarrhs, especially in ill-nourished children who are mouth-breathers, may cause opacities of the cornea, which are very slowly recovered from, and which for months or even a year or two may materially diminish the visual acuity. Small pustules from catarrh occur on the corneal margin, and are often very tedious in delicate children. They may cause dread of light, in which case the child should not be attending school.

Contagious eye diseases are more particularly seen in the unexercised low-resisting tissues of institution-reared children. They are rare in ordinary elementary schools. Rarely an acute inflammation of the eyes may occur in which the eyes are red and watery, the lids then swell and matter for several days, and after this slowly recover. The disease is contagious among the younger children, and sometimes spreads through the household from which the child comes.

A large number of children suffer from poor vision owing to defects in the structural dimensions of the eye. Such defects are called errors of refraction.

Errors of Refraction.—The eye has been described as developing from a flattened mass of tissue, which, growing at unequal rates, results in its globular form. This should be such that when the full-grown eye is at rest parallel rays coming from distant objects are focused on the retina. Under certain circumstances, which may be the result of differing conditions, as temporary illness, or overuse at different times, or many other conditions affecting nutrition and growth, the development of the eye in one direction or another may be modified.

Longsightedness or Hypermetropia.—The development of the eye may tend to be arrested or hindered. People in whom the structures of the head seem to develop unevenly, who, for instance, have long faces and narrow, highly arched palates, frequently have squint, commonly a result of hypermetropia. Their eyes have remained in the infantile condition, with their optical axes relatively short, i.e. the eye is shorter from behind forward than usual.

Such longsighted people, like the normally somewhat hypermetropic child, can only see distant objects by exerting accommodation. When not accommodating, distant rays of light (R, Fig. 23) are brought to a focus at F behind the retina, and a convex lens L is needed to ensure clear vision. The young child with longsightedness has great power of accommodation for distant objects; but in older people this diminishes, and convex glasses have to be worn, especially for near work. Even in children, if the hypermetropia is so great that there is any difficulty in seeing well, or any suffering from congestive troubles about the eyes, or red margined lids, the question of wearing glasses either constantly or for near work is worth con-

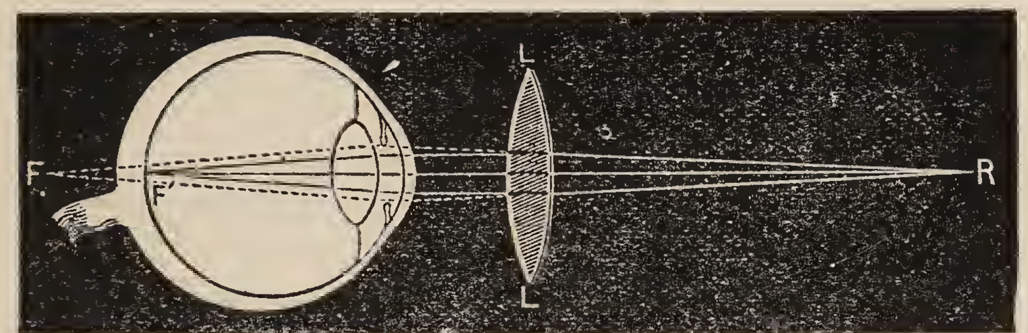


Fig. 23.—Section of hypermetropic eye.

R, the origin of divergent rays of light; F, the focus beyond the eyeball; L L, convex glasses to be worn by hypermetrope; F′, the focus of rays of light on retina, showing influence of L.

sideration. *If there is any doubt as to whether convex glasses should be worn it is best to wear them,* especially for near work.

Shortsightedness or Myopia.—In other cases either from debility or lack of resisting power in the tissues, after illness, in children of fine texture, and, as a rule, in people with broad heads, there is a tendency to over-development and stretching of the globe. The axis of the eye becomes relatively too long. This development is normal up to about the fifteenth, but is often continued till the twentieth or twenty-fifth year, after which elongation of the optic axis may be regarded as disease.

This physiological lengthening of the axis may be exaggerated by continued work with objects held near the eyes. The constant tension and sometimes spasm of the ciliary muscle tend to pull the front parts of the choroid and retina forwards; the pressure of the external muscles strongly converging and pressing on the globes tends to squeeze the comparatively unsupported posterior wall backwards; while at the same time the usual bent attitude of the head tends to general congestion and softness of the structures, so that in many cases such work produces a certain degree of stretching of the globe, with lengthening

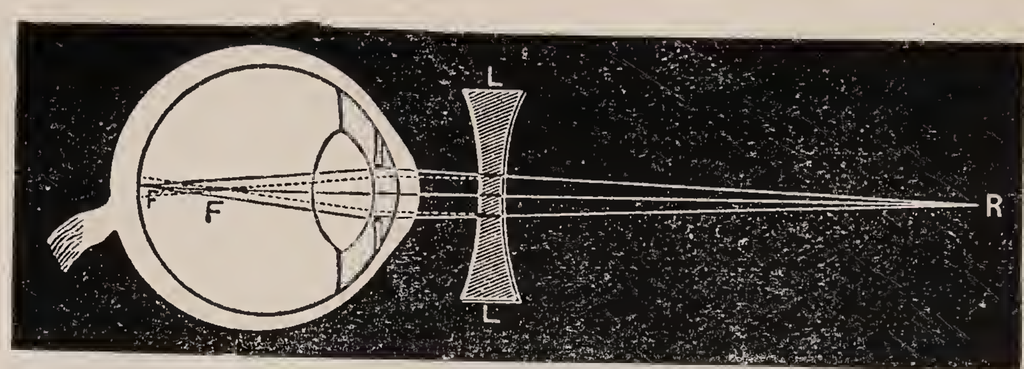


FIG. 24.—Section of myopic eye.

R, the origin of divergent rays of light; F, the focus of these in front of retina; LL, concave lens to be worn by myope; F′, focus of rays of light on retina, showing influence of L.

of the optic axis. Consequently, rays tend to be focused in front of the retina, and unless an object is brought within a certain distance of the eye it cannot be seen well. Many such cases in children are unreal, due only to spasm, and a warning about the dangers of oculists' and opticians' prescriptions for such cases has already been given. When there is actual lengthening of the optic axis the condition is called myopia.

Myopia exists in another form which is due either to disease or congenital weakness of the eye. This steadily gets worse till in middle life, from the retina becoming detached or hæmorrhage occurring, blindness may result.

This malignant myopia, common in Germany, is decidedly uncommon in England. These cases of "High Myopia" occur in quite young children, and progress rapidly during school life. Such children should not be permitted to do any fine eye work, and it is doubtful whether they should learn to read and write in the ordinary way.

Myopia is relieved by concave glasses, which render the parallel rays from distant objects so divergent that they appear as if coming from the farthest point at which the eye can see things clearly (Fig. 24). *If there is any doubt about wearing concave glasses it is better to do without*, and they should never be worn except after medical prescription.

The majority of children called shortsighted at school are not myopic. They may be hypermetropic or more probably belong to a large class who are astigmatic.

Astigmatism.—In astigmatism the growth of the eye has been so irregular that if a vertical equatorial section were made, it would not be circular, but elliptical. The long axis of the ellipse is usually horizontal, but it may be at any angle with the vertical. Such condition of irregular growth is known as astigmatism. According to the relation of length of the axis of the eye to the axis of this elliptical section the eye may for rays in different planes be hypermetropic, emmetropic, or myopic, i.e. longsighted, normal or nearsighted, or any two of these conditions may be combined. Such people cannot see a point clearly; it appears as a hazy or starred blur, drawn out in one direction. All eyes present this condition in a slight degree if submitted to a sufficiently fine test. To this cause the points of light in the heavens owe their name of stars.

In cases where the astigmatism is not very great, or when there is not much hypermetropia or myopia with it, a certain amount of correction is possible by the lens being strained by just a few fibres of the ciliary muscle contracting in one direction, and no evil effects are felt. In other cases, from constant or near work, this accommodative strain may set up severe nerve symptoms, pain, inability to use the eyes, headaches or neuralgia, which may be constant or more commonly intermitting but frequent.

Astigmatism requires correction in most cases. No optician or spectacle vendor, certificated or otherwise, should be allowed to prescribe the cylindrical glasses generally required for its correction, especially in the case of children. Symptoms are often only partially relieved, sometimes much aggravated, by their prescriptions, and the desirability of wearing them and the strength required is entirely a question for the medical man.

Spectacles.—No child presenting any visual defect is satisfactorily examined until it has been carefully measured with the pupils widely dilated by a mydriatic substance. Atropine drops or ointment is generally used for the purpose, and without this method the glasses provided by opticians or spectacle dealers, whether certificated or not, cannot be guaranteed as suitable for the children wearing them. It is commonly supposed that every child with defective visual acuity needs glasses, but there can be no greater mistake; some get no help from them, some do better without, and a very small number are found with defective acuity and no refractive error who in the course of a year or so attain normal vision. The abolition of glare in schoolwork is possibly more important than wholesale provision of glasses. A few children are damaged by glasses given them and with which they at first see better or clearer. It ought not to be necessary for a considerable percentage of young children to wear glasses. Even where adopted, certain considerations are of practical weight; thus the elasticity of the lens being unimpaired and accommodative power great, single spheres will generally improve vision so much and relieve strain so that nothing more is wanted. The correction of a diopter of astigmatism in children under ten is hardly ever called for; the prescription of bifocal glasses for children is a pure absurdity, and except in the rarest cases of highly neurotic children who happen also to be astigmatic, ocular headaches may almost be left out of account.

The school hygiene of vision may be concluded and summed up in the following extract taken from the instructions of one of the largest school authorities to its teachers:—

"It is exceedingly important that children should, as far as is possible, be prevented from acquiring the bad habit of working with a short distance from eye to work. In no case should any child be permitted to occupy itself with work nearer to the eye than a foot distance.

"In infants' departments, in girls' when sewing, in boys' when writing, or doing fine work or painting, they often bring their eyes down closely to their work, ensuring cramped chests, round backs, and much eye strain. During such work teachers should pay especial attention to prevent these habits, and endeavour to secure observance of a proper working distance."

CHAPTER XV

PHYSICAL EDUCATION

ALTHOUGH the term **physical training** is commonly used as if it were synonymous with muscular training, it is in fact more comprehensive. It embraces the physiological functions of the body and the recreative part of life. Hence it is concerned with sedentary games, the reading of light literature, the encouragement of pleasant conversation, etc., as well as with outdoor games and gymnastics. It is concerned with the training of each child in regular habits as regards eating, drinking, sleeping, and the functions of the excretory organs, and with every means by which the child's health may be brought up to a high standard and maintained at this standard throughout school-life. These objects ought to be as much the teacher's object as the instillation of definite knowledge; and the teacher ought to be in a position to send his pupil forth from the school with as good health as he possessed on entering it.

The muscles represent rather more than half the whole weight of the body; they contain in their substance about one-fourth of the whole volume of blood; and they have an active influence on the circulation of the blood, on respiration and on nutrition, besides being the chief producers of heat in the body. Most muscles of the body, being controlled by the will of the individual, are in direct communication with the nervous system, the nervous and muscular systems being both influenced by muscular activity. Thus muscular exercise is important during school-life because of its influence (1) on the general health, and (2) on the brain.

1. **Influence of Muscular Exercise on the General Health.**—The muscles themselves can only be made and kept firm, large, and strong by regular exercise. Muscular work is the chief source of heat in the body; the circulation of blood is improved and rendered more uniform, and consequently cold feet and chilblains are avoided. The lungs work more actively during muscular exercise, so as to supply the increased amount of oxygen required. Thus the respiratory capacity is increased, the tendency to a flat-chested condition is averted, and the liability to chest ailments is greatly diminished. The improved nutrition is shown by the better appetite and the improved digestion which are caused by exercise. Indigestion and allied troubles chiefly occur in persons of sedentary occupation.

The following tables from Maclaren's *Physical Education* show some measurable effects of systematic gymnastic exercises. The first table shows the effect of seven and a half months' training of men varying in age from nineteen to twenty-eight, the average age being twenty-four, and the men having been irregularly selected:—

	Weight.	Chest girth.	Girth of fore-arm.	Girth of upper-arm.
	lb.	in.	in.	in.
The smallest gain . . .	5	1	$\frac{1}{4}$	1
The largest gain . . .	16	5	$1\frac{1}{4}$	$1\frac{3}{4}$
The average gain . . .	10	$2\frac{7}{8}$	$\frac{3}{4}$	$1\frac{3}{4}$

The second table shows the effect on two articled pupils, aged sixteen and twenty, of a year's steady practice in gymnastic exercises.

In the year's work the increase was—

	Height.	Weight.	Chest.	Fore-arm.	Upper-arm.
	in.	lb.	in.	in.	in.
With the younger .	2	21	5	2	2
With the elder . .	$\frac{3}{8}$	$8\frac{1}{2}$	6	$1\frac{1}{4}$	$1\frac{1}{2}$

2. **Influence of Muscular Exercise on the Brain.**—During the period of school-life the brain and muscles are both undergoing growth and development. They cannot be separated from one another, being intimately in communication by means of nerves. The musculature of the body is doubly represented in the brain; on the surface of the motor convolutions there are centres corresponding to the several muscles of the body, and here issue all voluntary impulses resulting in muscular exercise; these impulses are, however, under the control of certain sensory convolutions wherein are stored the memories of sensations derived from past muscular contractions giving ideas of weight, distance, and resistance. These extensive regions of the brain are in intimate communication with all the other regions of the brain, and at the same time it can attain its full vigour only when the whole muscular system is in a well-developed and healthy condition. It is a well-known fact that each nervous centre requires external stimuli to develop its potential power. If a number of chickens are hatched on a carpet they will run about without attempting to scratch until a little gravel is scattered upon it. The congenital absence of the left hand and atrophy of the left arm have been found after death to be associated with an imperfectly developed condition of the convolution of the brain in which movements of the hand originate. But where death has occurred some years after amputation of the limb of an adult no obvious alteration in the corresponding part

of the brain has been found. Hence the greater importance of exercise before twenty than after that age.

The above considerations render it evident that the development of a considerable portion of the brain is dependent on muscular exercise, and the non-recognition of this principle has been saved from calamitous results in the past only by the instinctive revelling of children in movements of every kind.

The preceding general considerations show the importance of **physical education.** Education, as we have seen, has a much wider meaning than the mere acquiring of a given amount of information. The bodily and mental functions are closely interdependent, and the harmonious working of the two can only be secured by training which is devoted to the muscular system and the special senses, as well as to the intellectual powers. This principle is now recognized in the Code of Instruction for Elementary Schools, which recognizes as part of the school curriculum, and allows a portion of the school time to be apportioned to instruction in—

Manual Instruction;
Suitable Physical Exercises, e.g. Swimming, Gymnastics, Swedish Drill;
Military Drill, Cottage Gardening (for boys);
Practical Cookery, Laundry Work, Dairy Work, Practical Housewifery (for girls).

Some scheme of physical exercises is therefore now required as a regular part of schoolwork, although with healthy organization of child life this should be quite unnecessary. At its best such a scheme can only be regarded as a necessary evil due to the artificial life which follows highly urbanized conditions, involving hours of daily desk work, and restrictions on play and movement, an evil rising from want of space in towns, which in this respect is harmful. This holds not only for England but for many parts of Greater Britain as well.

Only the broadest principles of exercises can be now discussed. Any system must have a framework of uniform words of command and the exercises resulting from them; this part of the scheme ought to be reduced to a minimum. The extraordinary detail given of many so-called errors in performance, and the meticulous care asked for in children's work is absurd when the value is considered in respect of child welfare.

The main purposes of exercise are firstly the promotion of nutrition; secondly, and more remotely, the development of neuromuscular co-ordinations; and lastly, the correction of defects.

In all its functions the body should work well within its capabilities, with a considerable reserve which can be called upon. While living in a natural state of savagery or wildness, reserves were probably developed, and life went on at a level which maintained the reserve, to be called upon now and then, as in hunting, fighting, and so on. Nowadays these reserves are scarcely ever called forth, and but rarely properly developed. The young child seldom has the abundant rough-and-tumbling play which nature requires to bring out its qualities. A team of football boys were each made to run at top speed up and down stairs. Their pulse-rate was taken for some time before and after, and then watched till it became normal; this averaged about three minutes. A number of girl students training as pupil teachers were made to do the same work; many did not recover their original rate for over half an hour. In the one case some reserve capacity had been developed, in the other it did not exist. So one might take breathing, running, or other bodily functions, and trace out reserve powers or their want.

The promotion of nutrition means keeping the tissue cells in full functional vigour, and not only a few but all the cells. It is no use having excellent muscle fibres if the phagocyte cells of the blood and tissues, which deal with the dangers of bacterial poisons or the germs themselves, are already overloaded or weakened by an excess of waste products such as fatigue toxins. Overwork, indeed, is one of the predisposing factors to loss of immunity; it is the chronically overworked artisan who most easily falls a victim to tuberculosis, and even the athlete in full training is in a dangerous condition in this respect; all his reserves have been sacrificed to muscular performance, he can scarcely resist the ordinary cocci of the skin and becomes very liable to boils; should he get pneumonia he is likely to die. The man who will probably live long and do good work is the man with a sound heart and good, big, healthy lungs.

Lymph Movement.—The nutrition of the body cells depends on heart and lungs, but they act secondarily through accessory factors nearly as important as the heart and lungs themselves. Nutrition requires an abundance of utilizable food material, including oxygen, being brought to the cells, in the serum of the blood. A particular mechanism exists in the hæmoglobin of the red corpuscles, which acts as a carrier of gases far beyond the capacity of the serum, taking oxygen to the tissues and removing the product, carbon dioxide. The part of the blood which passes out of the capillary vessels comes in actual contact with the cells, takes up waste materials, and as the lymph of the tissues aids removal of this waste. The due and brisk movement of this lymph is about as necessary for good nutrition as the movement of the blood itself. It is this drainage movement of the lymph which is the chief purpose of physical exercise as an aid to nutrition. The benefits of increased respiration and circulation to be obtained from exercise largely depend on their action in promoting lymph movement. Other equally important contributories, which will be dealt with in connection with ventilation, are heat removal and evaporation from the surface of the skin.

The lymph is collected in an enormous network of fine transparent vessels, the lymphatics; these are abundantly supplied with valves, only permitting the contents to pass centripetally. These vessels carry their contents to the lymphatic glands, where active digestion and destruction of toxic matters takes place, after which the fluid is carried on, to be poured into the great veins at the root of the neck.

Owing to the structure of these lymphatic vessels, every movement of the body, active or passive, results in the forward flow of their contents, promoting lymph circulation and removal of waste products from the tissues. Without a full appreciation of these facts the nutritive action of active or passive exercises, and the importance of their extension over wide areas of the tissues, will not be appreciated. The omission of reference to lymph movement in the theoretical introduction to the official Syllabus of the Board of Education probably accounts for the failure of the "two-minute" exercises to gain wider use.

The nutritive effects of massive simple and rapid movements, which are described as recreative exercises, are greatly dependent on the massaging effect of the movement of great muscular masses, which also, without much tax on the nervous system, provide sufficient of the chemical products of fatigue from the working of the muscles themselves to stimulate the nervous centres for circulation and respiration. These functions by their effects in powerful movements of the diaphragm and other respiratory muscles, as well as rapid pressure changes in the chest, produce a movement of lymph which sweeps out the accumulation of waste products locally without any great expenditure of nervous energy, thus not only stimulating nutrition but also relatively relieving fatigue. These exercises to do good must be repeated many times a day, certainly for not less than half a dozen times, and for not more than two to three minutes at a time. The whole purpose is by large movements, rapidly and easily done, to get a flushed face, a quickened pulse, and rapid respiration. The best way of doing this is by rapid running, jumping, or dancing. The younger the children the more important is it to have frequent two-minute exercises.

Cool, moving air stimulates and refreshes; it is an additional help, but as yet often a luxury, and the opening of windows, whilst to be recommended, should never stand in the way of frequent short, sharp, but large and massive exercises. It must be insisted that if school air is not good enough for two-minute exercises it should be condemned.

The practice of deep breathing exercises as followed in schools is a comparatively useless proceeding, except in so far as it develops muscles which may be useful to the singer, and also, by vigorous action of the diaphragm as a pump, promotes lymph flow. Indeed, there is a natural stop action to deep breathing provided, in that a certain amount of carbon dioxide is necessary in the blood to set the nervous mechanism of breathing going; if this amount fails, breathing stops till it reaccumulates. The holding of the breath by young children whilst one, two, three is counted, at the end of an inspiration, is rather harmful. In the case of some enthusiastic teachers, deep breathing work has resulted in acute emphysema, and recovery has required prolonged absence from work. The chief use of deep breathing in school is to see that there is no nasal obstruction. The effect in disseminating colds or catarrhs should be remembered. All breathing exercises should be done with the mouth closed; but in infants, if there is nasal obstruction, this may tend to actual deformity of the chest walls, the lower portions being pressed inwards, and then treatment is necessary if the opened mouth is to be avoided. The idea that adenoids or enlarged tonsils commonly hinder the proper aeration of the blood is, however, not based on any facts.

It may be summed up that for nutrition the respiratory and circulatory movements which are physiologically of most importance are those automatically developed by the action of large muscular masses in a short space of time. The proper way to develop both respiration and circulation is to provide time and space for frequent periods of play for young children with short, violent bursts of effort. This variety of exercise is of greater importance than any formal systems taken in lessons.

Educational Effects of Physical Training.—The cyclist in learning is bruised and stiff with the enormous efforts he puts forth, but the accomplished rider goes all day without much trouble. It is possible to isolate or focus muscular movements so that the maximum result is got from the minimum effort ; this is obtained by training. By these focused movements special exercises can be devised to remedy conditions chiefly of growth and debility, or habits of posture and fatigue, due to the want of healthy childhood, absence of handy and convenient playgrounds, deprivation of fresh air, and insufficiency of good food. Flat-foot, lordosis, and other postural defects can also be treated in mild cases by exercises directed to the weakened muscles.

Beyond teaching the drill sufficient to get quick and regular movements in masses of children, to fill or empty classrooms, dismiss school, and so forth, complicated systems of physical exercises, such as the long official Syllabus, ought not to be necessary in the elementary schools. As taught at present, whilst some little good is done, the lessons usually appear boring to both children and teachers. Something better must be sought, which, while interesting, is likely to be kept up easily after school days, under town conditions. Dancing and skipping seem most probable forms of good, interesting exercises suitable also for nutritional purposes.

Singing should be specially mentioned; regarded as an exercise it is a wholly artificial performance, and requires special training and deep breathing to develop the management of the respiration. The control of the respiratory muscles has to be got in a way which has little relation to physiological needs. Apart from singing, these exercises are not wanted by most children, and singing, indeed, ought to be rather a spontaneous and imitative exercise than the result of formal training.

Considerable rest periods are as necessary as exercise for nutrition. This has to be remembered, especially in residential schools.

Ignorance of the needs of childhood is still extensive, and the following extract from a published report on a suburban school well expresses and sums the conditions found: "The children are of a respectable class. They are well fed and clothed, but are altogether a flabby and pappy lot. Almost all have palpable glands in the neck. The head teacher returned over a hundred as defective; this seemed absurd until the children were examined, then the oft-repeated note of 'delicate' is justified. The children are too respectable to play in the street; their back gardens or house rooms are small, so they do not compare favourably, save in cleanliness, with children in poorer quarters who play freely in the open air. The teaching of hygiene is needed in the district."

Exemption from Exercise.—All children should be given the school exercises in use, unless there are distinct contra-indications. Many ill-nourished and debilitated children in school cannot go through the lesson without weariness, actual physical suffering, or even faintness. Any child becoming pale in the face, especially if with a drawn look about the mouth, should be put to one side at once, and only gently exercised for some weeks; indeed, a child giving rise to anxiety is probably better doing other work.

A child convalescent after zymotic disease, like measles, diphtheria, or influenza, and all children suspected of tubercle, must exercise cautiously. Children with recent rheumatism, growing pains, chorea, or even marked anæmia, must be specially watched; they have often irritable or weak hearts liable to dilatation, if not more serious disease, and should only do the lightest exercises, avoiding stoopings or body bendings. Any child showing marked shortness of breath, which occurs readily or persists, is at least doubtful in regard to the heart, and should be kept back. The majority of chronic heart cases do well with light exercises, but care and observation are needed until the doctor gives his verdict. Certain other less common conditions like asthma, migraine, or tendency to nose-bleeding, should be excused. Girls about puberty who show fine tremor of the extended hands and fingers, rapid pulse, and some fullness about the neck require excusing for a time; they are easily exhausted and often suffer from headache or have emotional attacks after much exercise. If in the slightest doubt about a case it is well to have medical advice.

Spinal Curvature.—Certain deformities occur from weakness or debility of muscles or tissues, yielding either through fatigue or as the result of mere weight. If strictly looked for, they can be found in some form or other in about half of the elementary school children.

Many of these deformities, like shortsightedness, appear to increase in frequency and degree with school-life, but school is not a primary cause, although in cases so disposed it may be a contributory factor. Aggravation of symptoms occurs under certain conditions which appear to predispose to fatigue or debility. This is most evident during rapid growth in height. Often arrest in growth during illness is made up in convalescence, a time also for aggravation of the deformities of weakness, like myopia, spinal curvature, or flat-footedness to show up. Other factors tending to debility, such as insufficient exercise, long hours in school desks, or overheated rooms may be mentioned. In young children rickets is a great source of deformities.

Spinal curvature is the commonest; it is sometimes spoken of as a school disease. Most cases are slight, many are attributed to right-handedness, to carrying weights, satchels, or books, under the arm, or even to having been always carried on the nurse's left arm in infancy. Most are developmental irregularities which improve later. There are antero-posterior curves. Exaggeration of the normal backward convexity of the spine is commonest; it is termed *kyphosis*, and is shown by a slouching, rounded back, with chin poked out, a flat chest, and protruded abdomen. When told to hold themselves up, these children usually throw the shoulders back and protrude the abdomen more, strongly arching the spine below to exaggerate unnaturally the backward concavity, producing *lordosis*. If these conditions persist and become fixed a very great deformity may result.

Lateral curvatures in slighter forms are largely mere developmental irregularities. A lateral curve may be either to the right or left, and is called *scoliosis*. It is predisposed to in children with weak backs and sloping shoulders, but it is not always possible to say which are likely to develop into bad cases, so that all have to be observed. Some 25 to 30 per cent. of children show *scoliosis*, and about one-tenth of these require systematic treatment. Boys and girls appear to figure equally in school inspections, but girls present most of the severe cases.

Cases may be classified in three degrees: first, those in which the condition disappears on change of posture or by pressure of the hand; second, those in which it is improved but does not disappear; third, those in which it persists in spite of posture or pressure. Curvatures to the left are commonest, and are usually associated with some *kyphosis* or stooping; the writing position tends to

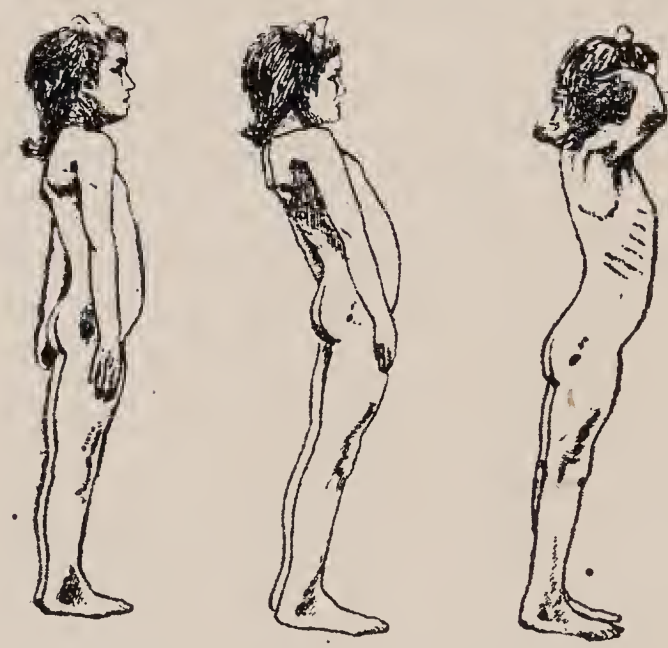


FIG. 25.—Kyphotic child, showing ordinary, over-corrected, and correct attitudes.

develop this defect. When the child is stripped and stands up with its back to the observer the curvature shows; the shoulder seems raised on that side, and the opposite hip is more prominent.

The school can do something towards prophylaxis. Early detection is required by medical inspections. Healthy schoolrooms, suitable desks, no protracted sitting in desks, and no bad attitudes should be allowed. Failure to maintain good posture is probably the school factor most tending to aggravate these conditions.

Daily exercise and rest in the corrected position cure or improve two-thirds of the cases. For some years regular school classes have been used in Germany for many of these cases, but it is doubtful whether any but early or slight cases are benefited. Where what is known as the creeping method is used, children crawl in a circle, so that the spine is bent against the curvature; the children have to attend for many months or even years. Severer cases must be treated by good regimen, rest, and definite corrective exercises in a proper gymnasium.

Flat-foot.—This is a condition which before the war caused the rejection of up to one-third of the recruits in some European armies.

Some children have weak feet from the leg muscles not supporting the foot in standing, and all the strain falling on the ligaments, the foot being of normal shape when at rest. In true flat-foot the ligaments become stretched, so that the inner edge of the sole touches the ground, and with a wetted sole the whole surface makes an imprint, the healthy foot only making the imprint of heel, toes, and outer side. About one-third of the children in poorer schools have some degree of flat-foot. Much heavy work, out-of-school work, heavy and unyielding boots, and clogs especially, dispose to aggravate flat-foot, particularly in weakly or ill-nourished children. Anything which displaces weight from the ball of the foot or towards the inner side, and certain positions, the turning out of the toes, for instance, in teaching infants to walk, or in physical exercises, tends to develop the condition. The absurd *Parademarsch* (goose-step) of the German soldiers, turning and pointing the toes down and out, causes the defect. In walking, the feet should move in parallel lines passing through the centre of the heel and the big toe. Walking on tiptoe, or going tiptoe upstairs silently, dancing or skipping on the toes, are useful exercises, the feet being in good positions.

Painful feet should always be submitted for medical inspection, lest serious disease, like commencing tubercle, be missed. Many children suffer from perspiration, which, with ill-ventilated shoes, may be offensive. It readily yields to the use of powdered boracic acid as a dusting powder after washing, and in the socks and shoes.

After middle life, with relaxation of tissues in those who from want of exercise are so disposed, and who, like most teachers, have much standing, flat-floot may give trouble, and requires treatment by supports.

CHAPTER XVI

SLEEP AND REST

Sleep is the most complete form of rest. During sleep the flow of blood through the brain is much diminished, and consciousness ceases. Some mental action still continues, and in shallow sleep dreams may be partially remembered, a fact throwing some light on hidden mental action. If a child eats and sleeps well, the brain is almost certainly not being overworked. On the contrary, where there has been excessive mental work, the effects of this cannot be entirely compensated by prolonging sleep. The mental work must be diminished, and more time allowed for recreation. Where sleep has been lost, the effect of a single night of loss may be detected by psychological tests for nearly a week, although the sufferer may be quite unconscious of it otherwise.

In some observations on young animals, total loss of sleep seemed more important than loss of food. On the other hand, after deep sleep there appears to be a period of lessened mental capacity. Observations on the Continent, where a midday rest is the rule, showed that subsequent mental capacity varied with depth of sleep.

The nursling in the vegetative stage of growth chiefly feeds and sleeps, and the younger the child the more sleep required. The brain is rapidly increasing in weight till seven years of age, and till then the child has need of much sleep. It should certainly not pass twelve hours without. The best sleeping-time for the youngster under seven is an hour or more between one and four of the afternoon. Much of the success of the open-air schools in both England and America is due to the unconsciously adopted regular midday rest picked up from the Charlottenburg school. Every infant mistress knows that many of her charges will sleep and that all would be better if they could. It should be a requirement of the Board of Education that every child under seven in infant schools must have at least forty minutes' quiet and undisturbed rest after midday. Where provision has not been made for hammocks, some mistresses have turned the small tables upside down and with coarse canvas and tapes at the corners constitute a hammock slung from the table legs and sufficient for an infant.

Amount of Sleep.—The standard for what is sufficient sleep has been generally accepted as that recommended by Dr. Dukes, of Rugby, who gave thirteen hours for seven-year-olds, down to nine hours for sixteen-year-olds. Numerous inquiries in elementary schools all give results much short of this. But children as well as adults have individual differences, some needing much more than others. Napoleon the Great is said to have rarely slept more than four hours at a time.

The spontaneous sleep of children probably depends on climate, social stratum, and housing. Schmid-Monnard, in Halle, found seven-year boys to average twelve hours, eleven hours at fourteen, and nine hours at eighteen. In California, where the conditions of life are probably much easier, Terman fixed 11·15 hours between six and seven, 9·31 hours at thirteen to fourteen, and 8·54 hours from fifteen to sixteen. These are about an hour above the values usually slept in England as determined by Miss Ravenhill. Terman obtained no relation between sleep and school subjects; he thought the quality of the earlier sleep was most important, and that the value of mere duration was overestimated. The quality of sleep is much interfered with by bad housing in large cities, where there is scarcely room for children to live and the majority of children have to sleep two or three in a bed, disturbed by the comings and goings of adults, and often troubled by smaller bed-fellows, who give little rest, especially in the warm summer. The temperature of the room if over 65° tends to prevent sleep, and bad ventilation may render it unrefreshing.

Professor Sakaki, from æsthesiometric studies, says Japanese boys require half an hour's longer sleep than girls of corresponding ages.

Probably for all young children the sleep requirements would be best met by securing as undisturbed rest as possible in the earlier part of the night, and also the securing at least one rest hour between noon and four in the afternoon.

Sleep may be disturbed pathologically. Night terrors occur in many nervous children. The child may waken, screaming and pale, not able to recognize others, and inarticulate with fright, or having seen some terror or other. These nightmares are nerve storms, some of which are of an epileptic nature, some associated with adenoids, whilst the majority of sufferers seem to be merely nervous, rickety children. The condition is not one to neglect, as such children may suffer severely later. The child who does sums in his sleep is also nervous, but is merely dealing with the strange things of his experience beyond his home, and although the sums may not be the cause, still talking in sleep suggests abnormal excitement, and it is often an early symptom of disease; it may be a feverish cold, or latent rheumatism, or even beginning meningitis. Bed-wetting occurs in nervous children, but it is commonest among children who have not been taught good habits;

it is often associated with nail-biting; such children, becoming hospital patients, are generally taught better by the nurses in a very short time. It is not an infrequent symptom in mentally defective children; sometimes, however, it is due to the irritation of parasites or even to excessive drinking late in the day. Withholding fluid after five o'clock works a charm for many, and where acidity is the cause, barley-water for a few days may be helpful. Some cases are relieved by adenoid or nasal operation; a few are found who must be turned out of bed last thing at night; and even then some remain who are almost incurable. In a few cases early morning attacks, which are really epileptic fits, are mistaken for terrors. The child may not cry out; it may, however, bite its tongue and stain the pillow, or it may wet the bed, and these may be the only indications of epilepsy for years. Such children are occasionally punished for inattention in school on days subsequent to their attacks. Where difficulty of going to sleep exists, school worry, or overwork, is to be suspected. Worry may exist in quite small children, and in such cases quiet and soothing kindly talk is the best treatment, but its real sources are probably beyond the school. It is the older pupils, especially girls or teachers, who are sleepless from overwork. A good rule is a fixed hour for bed, from which there is no departure, and an absolute cessation of all school tasks at least half an hour previously. Tea or coffee must always be remembered as contributory causes of wakefulness. Persistent insomnia after childhood is sometimes the expression of eye strain, without other noticeable symptoms, in astigmatic cases who may show good visual acuity.

CHAPTER XVII

NUTRITION AND DIET

Food and Growth.—The diet of children should be generous and abundant.

There is no danger of giving too much food, if only simple and wholesome dishes are allowed. After forty it may be broadly said that the chief danger in regard to diet is of overfeeding, under twenty of underfeeding. It must be remembered that during youth, and up to the age of twenty-five, physiological processes are more active than at a later period; freer exercise is usually taken, and, in addition, food is required not only to supply energy for carrying on the functions of the body, but also for purposes of growth. Children have to make new tissues as well as to keep in repair those already formed. Also as their bodies expose more surface, in proportion to bulk, than adults, they require a proportionately larger amount of food to compensate for loss of heat.

It is, in the main, only after waste of tissues and loss of heat have been provided for that any surplus of nutriment goes to the further growth of the body. If the food supply is scanty, one of two things must happen: growth will be impeded, and children will be stunted specimens of humanity; or some of the organs of the body, as the brain, or muscles, or bone, will suffer in functional activity and may eventually become the seat of actual disease.

The younger an animal, the more easily is it starved; and the more actively growing are its organs, the more seriously they are injured by partial starvation; and the same applies to human beings.

In the ultimate analysis, human or any other life appears to have two chief purposes: the first is nutrition of the body, and the second continuance of the race.

In the growing individual, nutrition is the most important thing; if that is unsatisfactory, every other consideration must be pushed aside until it is righted. Questions of education are but vanity, and to raise thrift or self-help into discussion is hypocrisy, if these things stand in the way of remedying ill-nutrition in the child.

The ill-nourished individual has little reserve, either muscular or vital, being easily liable to fatigue; the accompanying conditions also render facile bacterial invasion. The ever-present tubercle bacillus then finds opportunity for renewed growth. The various organisms which normally maintain unobtrusive existence on the skin and mucous membranes assert themselves as sores and breakings out, catarrhs, running ears, corneal ulcers, or in the blepharitis and sore lids which are only common in the weak and ill-nourished. The lymphatic glands, too, often give evidence of some enlargement from bacterial invasion badly dealt with.

Many of the cases which are slurred over as simple amentia are cases where the rhythm of development appears interfered with, being retarded by ill-nutrition, and instead of being spread over a long time, their physical evolution is late and unsatisfactorily accomplished in a short time; meanwhile their brains respond poorly to the demands of education. Dr. Crowley in Bradford noted that children of exceptional intelligence were 62·7 per cent. good nutrition, whilst dull children had only 24·9 per cent. good nutrition. Nutrition, then, is a complex which may be very difficult to assess. It is a condition in which is summed the whole environment and past history of the child.

It has already been seen that every cell is harmfully affected by the products of its own activity (fatigue) which require removal, and that for healthy nutrition of the cells good lymph and blood circulation are required, necessitating stimulation by exercise, removal of heat and moisture by cool, moving air, and sufficient time for cell recuperation in rest and sleep. These things every school child needs, although most lack some at least, in sufficiency. They are discussed under their several headings. Far beyond these, however, in importance for the growing child, is sufficiency of food. The proposition is quite incontestable that want of sufficient food, starvation, is the main cause of ill-nutrition in the elementary school.

The only reliable way of assessing nutrition is from the estimate built up by a trained observer during a clinical examination. Measurement, and such mechanical means, may serve for groups, but fail signally with the individual, and it is only by application to the individual that any estimate becomes of value. This tends to be forgotten in the heaping up of meaningless and unmanageable piles of figures, which have become fashionable and give a spurious appearance of definite and accurate results to official reports. The estimates of nutritional condition hitherto published regarding masses of children scarcely inspire confidence, e.g. subnormal and bad nutrition exists in 1·2 per cent. in Rhondda, 9·5 per cent. in Willesden, 15·7 per cent. in Brighton, and 26·3 per cent. in Norwich, according to the figures given in the Board of Education Report for 1912. The healthy child up till four or five is chubby and fat; then a lean period follows for several years with the commencement of the second dentition, followed by another couple of chubby years, and again the lean and lank growth up to puberty. If these periods are remembered, no one will fall into the sad error of attempting to compare entrants with leavers by percentages of nutritional conditions, and from these figures speak of loss or gain during school-life.

The judgment of nutrition is much affected by surroundings; a doctor, for example, tends to mark the later cases seen more leniently even in the course of a single session. Fatness and colour are both evidence of nutrition. Probably for any tabular or statistical purpose children should first be estimated as either normal or anæmic. These two classes should then be noted as poor, fair, or good nutrition, according to the general textural solidity and tone of skin, muscle, and subcutaneous fat.

A very useful method of making the last classification is that of Wimmenaur, who inspects the child in an oblique light, and classifies by the condition noted in the thoracic walls as (1) well nourished, when the intercostal spaces are scarcely noticeable; (2) when the spaces below the nipple level show between the ribs the child is fairly nourished, and (3) when the spaces show deeply, and appear also above the nipples below the great muscles it is poorly nourished. Girls have to be more strictly judged than boys, as they tend to be fatter.

Other circumstances furnish indications in loss of muscular tone, cold blue hands, harsh dry skin or hair, blepharitis; or fatigue signs, such as lassitude, mental dullness, tired, half-shut eyes, often puffy-looking or with dark rings round them. The fat, lymphatic children, liable to bronchitis or catarrh, referred to on p. 185, are a good example of ill-nutrition from other causes than want of food. Ill-nutrition as the result of chronic products of disease is most commonly seen in tubercular diseases, often, however, a result of starvation.

Another method of valuation suggested has been by Oppenheimer's *nutritional quotient*. The maximum girth of the relaxed arm multiplied by 100, and divided by the chest circumference, at the end of expiration, gives a value about 29. A higher value is taken as indicating very good nutrition, whilst a value of 27 or less is taken as poor nutrition—all measurements being, of course, taken in the international centimetre and kilogram.

A more popular method is the *nutritional index* found by multiplying the cube root of the weight by 100 and dividing by the height. Somewhere about 80 per cent. of the ordinary school children give this index between 2·2 and 2·4. Cases with an index below 2·2 should be further noted regarding nutrition. The index varies with age from about an average of 2·65 at three years old to 2·27 at fourteen, and is generally greater for residential than for day-schools. A further age correction has been suggested, to get the index nearer a constant by multiplying it by the factor $\frac{\text{age} + 1}{\text{age} + 2}$. It then varies between 2·11 and 2·16. None of these methods is reliable for any individual case, and the average value of the fractions for considerable numbers will always vary with the time of year.

Nutritional Types.—Finally, for judgment of nutrition certain types have to be remembered. The thin-boned, gracile child of nervous appearance, with long eyelashes, downy hair on the back, and often over-developed cranium, is easily fatigued, and disposed to the various developmental defects, such as scoliosis, flat-foot, or myopia. This build especially may have the attachment of the end of the tenth rib to the sternum loose and wide. Usually, in most normal children, the end is beyond the nipple line, and cannot be felt or displaced up or down. In over 10 per cent. in some schools it can be grasped and moved, as its cartilaginous attachment is so loose, and it may even be felt as if free. This is known as Stiller's sign, and the loose attachment of the rib is supposed to favour displacement of the viscera down and forward, with various nervous and other symptoms as a result. In the majority of such cases there is found a tendency to weakness and nervousness, and conversely in an ill-nourished, debilitated child the chances of material and lasting improvement are not very hopeful if Stiller's sign is present.

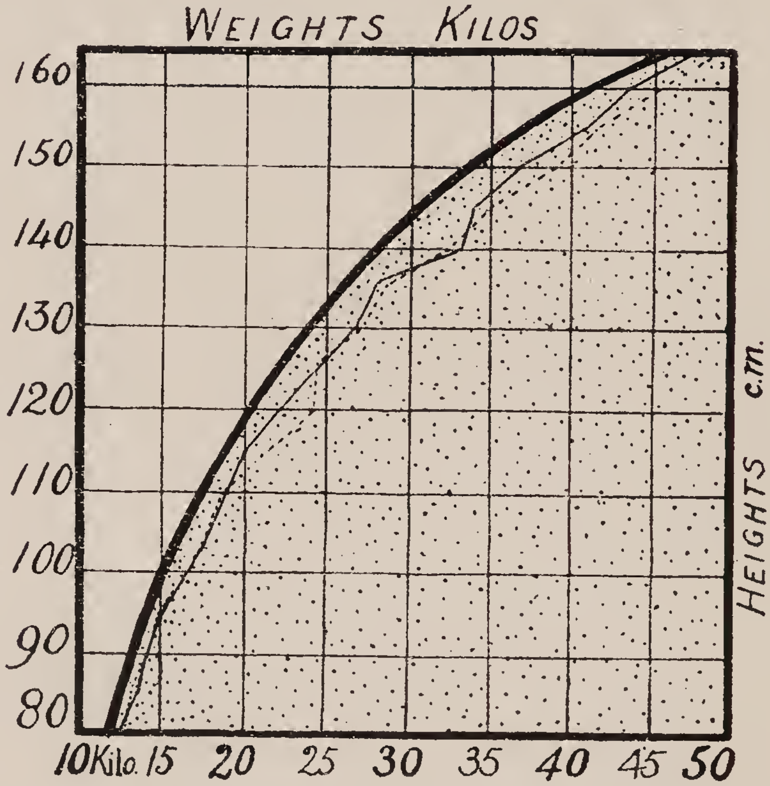


FIG. 26.—Relation of weight and height in good nutrition; based on Brighton boys, continuous, and girls, dotted curves.

Any child whose record would fall on the clear part of the diagram should be classed as physiologically necessitous in regard to feeding.

In assessing nutrition, race may have to be discounted, and recent illness, or the existence of definite disease.

When these considerations are balanced, it will be evident that the attempt to make nutrition *per se* a subject of statistical returns is faced by such enormous experimental error in the mass that it blocks out all possibilities of fair comparison. Descriptive words would afford truer ideas than figures, which here tend often to give a spurious appearance of accuracy.

One of the most practical methods is that adopted at Brighton, where the average weight for each height has been tabulated, and any child not up to the weight for its height is watched; it is taken that it requires feeding more than a child below both average weight and height for its age. The weights of the girls begin about the same as the boys, but with gradually increasing height the girls' weights also increase, till by the top of the height they are a kilogram heavier than equally tall boys. From the Brighton experience the diagram has been compiled, such that any child whose height and weight would fall in the clear space above the curve requires further inquiry as to nutrition. This method would also afford a rational discrimination of the children who need feeding.

Food.—School meals, which, as the Philadelphia Committee stated in their first report, "merely scratch the surface of a social evil," were originally organized about 1868 in France as *Cantines scolaires*. Various charitable efforts established and maintained a considerable amount of school feeding in England up till 1906, when legislation enabled authorities to spend up to the amount of a halfpenny rate on such feeding, and in 1914 various restrictions were withdrawn and a grant established. The feeding of a starving child is not a charity, but a duty of the State towards a future citizen. The State can settle up with others who should have performed this service, but towards the child it has the one urgent duty of feeding it and keeping it from want. This is being recognized, and during 1912–13, out of three and a third million children, 11·6 per cent. had some school feeding.

The estimation of the energy of food is determined experimentally in calories, the number of thermal units, given out in combustion. This calorie is, however, usually taken as 1,000 times that of the calorie, the C.G.S. unit of heat. The average heat of combustion of 1 gram of carbohydrate is 4·1 calories; of fat, 9·45 calories, and of protein, 5·65 calories. But allowance has to be made for the body not totally destroying these materials as food. By experiments on animals nearer values are found, as carbohydrates 4·1, fats 9·3, protein 4·1.

If the composition of a food is known the fuel values can be calculated. Milk is composed of about protein 3·3, fat 4·0, carbohydrate 5·0 per cent. respectively, and multiplying these quantities by the heat value of each, the fuel value of 100 grams of milk works out as 7·8 calories.

The food for an average professional man was found for himself by Professor Neumann, during ten months without gain of weight, to average 2,242 calories daily. He then lived more luxuriously, on roughly about 2,600 calories, gaining weight about ten pounds; and then again for eight months determined his consumption without losing weight as 2,000 calories.

Much depends on the work done. Whilst the sedentary life in the laboratory only took from 2,000 to 2,250 calories, this can be exceeded. A sleeping man will use about 6·5 calories per hour, but by very severe exercise a man can raise this expenditure to 650 calories in the hour. Some American estimates give approximate requirements as 2,000 calories daily for a shoemaker, 3,000 for a carpenter, 4,000 for a farm worker, 5,000 for a lumberman.

There is very little evidence as to the least amount of food required by a growing child. Dr. Chalmers Watson conducted an inquiry in Edinburgh on five-year-old children and assessed the daily requirements as proteids 72 grams, fats 69 grams, carbohydrates 198 grams, a total value in calories of 1,701. The School Board dinner he found as proteids 27, fats 9, carbohydrates 102, a heat value of 597 calories—much too scanty. Recently a carefully worked estimate on the Continent took it that the average child of eleven to twelve required 1,500 calories daily, of which 45 per cent. should be given in the midday meal, which would be 675 calories, but as the other meals are not likely to be proportionate, this was taken as 850 calories. The experience of boarding schools and residential institutions shows that a healthy boy in the later years of school-life requires nearer 3,000 than 2,000 calories, if he is to be sufficiently and well fed.

The growing child requires more food than would be expected if compared with an adult. A well-fed boy is generally ravenous, but poorly fed children, with debilitated organs, at school dinners can sometimes be hardly got to eat, and at first often refuse the food provided.

The meals given to children are nearly always deficient in protein and fat, and the child is stoged up with carbohydrates in the form of bread or pudding. It gets plenty of carbohydrate elsewhere, but the more costly protein and fat it does not get so easily. If a child is to be properly fed, nearly all the protein and fat should be given in the school meal. If the above points are attended to a suitable physiological dinner, including the service and food, cannot be given much under about threepence a meal. Dr. Watson insists that tuberculously disposed children, who are the majority of the ill-nourished, need excess of protein. He says that the protein of milk is much better than that of meat. School doctors generally agree that a cup of milk between eleven and twelve o'clock is an economical way of giving a fillip to nutrition. The fat of milk appears to contain a vitamine, one of a class of bodies small quantities of which are essential for growth and health.

One of the most valuable feeding experiments was the inquiry of Dr. Crowley in Bradford. He gave two meals daily, breakfast of porridge and treacle, bread and margarine, and milk, and a dinner, the amounts of protein being calculated at two-thirds of the child's requirement. His feeding cost four and one-fifth pennies a day. He calculated that on this basis father, mother, and five children require 18s. 8d. weekly for food alone, an amount which condemns as unsound the methods at present applied for selection on the poverty basis.

Properly worked, the school dining-room can be made as efficient a manufacturer of good citizens as the class-room, and the opportunities for social education are even greater. This promises to be realized in a few years; meanwhile the school medical officer has to keep in mind the conditions of Grant. This depends on organization, and selection of children, dietary, educational aspect, and suitability of accommodation, equipment, and service. There is an æsthetic quality of considerable physiological value in dining, as well as the administration of 800 or 1,000 calories value, and sufficient time and freedom, opportunity for converse, and intervals between items should be given. The dining-room should be properly appointed and warmed; there should be no waiting turns in the rain outside. The opportunity for washing is often, and any sanitary convenience occasionally, lacking. Tablecloths, where provided, are soon soiled by dirty hands and clothes, especially in places where school baths are wanted.

Some instruction in food values is of value as part of the training for girls. The Cheshire County Council some years ago issued a very good pamphlet on this, and among other items called attention to waste on costly foods in a statement which is broadly true:—

"Among expensive foods are cream, eggs, choice kinds of fish (salmon, sole, turbot, brill), and the choice cuts of meat. Calf's-foot and other jellies are of little value as foods. Meat extracts, meat juices, meat essences, broths and beef-tea are very wasteful foods for healthy persons. Many costly kinds of nourishment are no better than cheaper substitutes; for instance—

"Cod-liver oil is no more feeding than butter, fat bacon, or other fat.

"Cod-liver oil emulsion no more feeding than cream.

"Meat extract no more feeding than honey or treacle.

"Malt and cod-liver oil no more feeding than toffee.

"Revalenta is no more feeding than lentil or pea flour.

"Petroleum emulsion contains no nourishment at all."

Children require to drink frequently, and although in our moist climate this is not so urgent as in other lands, provision of drinking-water is always necessary. A separate drinking-vessel should be provided for each child at the school meal.

CHAPTER XVIII

DENTAL CARE

The new-born child is without teeth, but one by one during infancy the twenty teeth of the temporary set appear. The structures soon to form the thirty-two permanent teeth are hidden in the jaw underneath them. This gradual appearance of the temporary or deciduous teeth and their replacement by the permanent set is full of meaning to the biologist, and represents ancient stages of racial development which cannot be entered on here.

In rare cases, as is narrated of Richard III and Louis XIV, the child when born has a tooth or two in front, but usually the first tooth appears within a few weeks before or after the beginning of the seventh month, and by the twenty-fifth to thirtieth month the whole of the first set should have appeared. About the sixth year the first permanent molars come through. Considerable variation in these events is possible; thus, the first molars, commonly called the "six-year-old molars," may appear at five and a half, or exceptionally even earlier; on the other hand, they may be much delayed.

The average years of age for appearance of the other teeth may be set out as in the table on the opposite page.

If collated with other physical facts the condition of evolution of the teeth can be made useful in determining the physiological status of the child, whether precocious or retarded. It is noticeable that girls, in this as in other things, are, as compared with boys, somewhat precocious, having generally a tooth more than boys at the same age.

Teeth.	Boys.	Girls.	Teeth.	Boys.	Girls.
Inner Incisors	$7{\cdot}5 \pm 1{\cdot}4$	$7{\cdot}0 \pm 1{\cdot}6$	Canines . .	$11{\cdot}2 \pm 1{\cdot}4$	$11{\cdot}3 \pm 1{\cdot}0$
Outer Incisors	$9{\cdot}5 \pm 2{\cdot}1$	$8{\cdot}9 \pm 2{\cdot}1$	Second Molars	$13{\cdot}2 \pm 2{\cdot}0$	$12{\cdot}8 \pm 1{\cdot}6$
Biscupids .	$9{\cdot}8 \pm 1{\cdot}6$	$9{\cdot}0 \pm 2{\cdot}8$	Wisdom . .	$22{\cdot}2 \pm 1{\cdot}7$	$21{\cdot}8 \pm 1{\cdot}8$

Teeth may be regarded, like hair or nails, as particularly modified skin structures. A small process of epithelium of the mouth grows down to form an enamel organ,

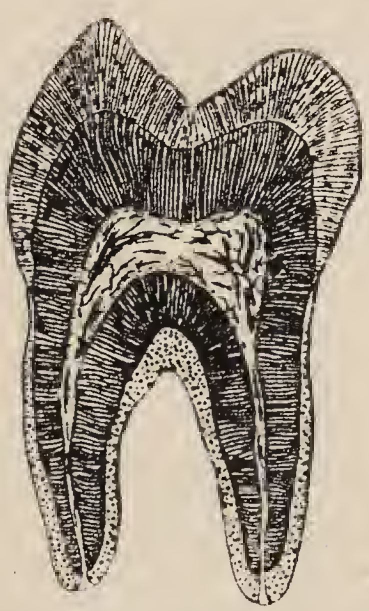


FIG. 27.—Diagrammatic section of a molar, to show the enamel covering of the crown, the dentine, with the pulp cavity and nutrient vessels, and the cementum covering the roots.

which, meeting another process, the dental papilla, develops, according to its situation, to form one or other of the teeth. The general plan of the tooth is a solidly constructed crown, which appears above the gums, joined by a neck to one or more roots or fangs, by which it is embedded in the alveolus of the jaw. The greater part of the tooth is made up of dentine, a hard, ivory-like material, laid down in structure radiating from the central pulp cavity, which cavity extends through the roots to receive blood-vessels and nerves from the structures of the jaw. The nutrition of the tooth depends on this pulp and on the dental periosteum. The exposed surfaces of the tooth are covered with the enamel, which is the hardest material in the body. The roots have an outer coat of bony material, the cement layer.

The growth of the permanent tooth germs goes on in the jaws below the temporary teeth. The roots of these last are gradually absorbed, till finally they are so slightly attached that they are displaced by food, or can be flicked out with a finger-tip. Sometimes, but rarely, children are seen in school with a double row of teeth in front, the deciduous set still remaining and the permanent teeth having erupted almost parallel to them.

Defects.—It is a popular error that the temporary or milk teeth are not of importance, and so they come to be neglected. Disease in these teeth, however, often results in defects in the permanent set. The milk teeth are laid down in structure long before birth, and the formation of the crowns of the permanent teeth has already well commenced by the second year of life.

The commonest defect in teeth which increases liability to future disease is irregular, defective, and deficient structure of the enamel, known as *hypoplasia*, which produces honeycombed teeth. In the temporary set this would be due to ill-health in the mother, producing defective dental nutrition in the child before birth. It is, however, in the permanent teeth that the condition is of such serious importance, and then it is usually due to malnutrition in the first couple of years of life.

Rickets is the commonest cause. Syphilitic disease may also be a cause when inherited; it most commonly results in a defective growth, which shows as a notch at the middle of the edge of the central permanent incisors. The occurrence of any disease disturbing nutrition may be shown in the teeth later; for instance, measles at an early age may leave its permanent record as a small horizontal groove or series of pittings in the enamel of teeth which appear years later. Another cause of misplaced front teeth and distorted jaw from protrusion is the septic condition and mechanical pressure the result of using a

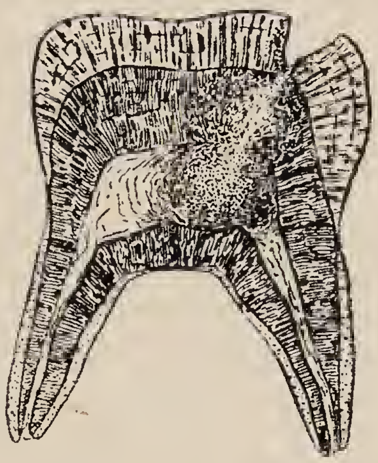


FIG. 28.—Breach in enamel of molar, resulting in invasion of dentine and pulp cavity.

dummy teat, or even of thumb-sucking. Any defect in the enamel is serious, in that not only are the teeth more fragile, but decaying material, as decomposing food, accumulating there, may at last attack the enamel, and if this is perforated, the more vulnerable dentine yields easily and extensively. It is soon softened, and inflammation ultimately starts in the pulp cavity, often resulting in loss of the tooth. This is the frequent cause of toothache and dental abscess.

Caries.—Destruction of the enamel by acids, often produced by germs in fermenting food remains, constitutes dental caries, the commonest disease of civilization. C. E. Wallis has pointed out that the worse and more poverty-stricken the class of school child, the better the teeth; this he takes to mean absence of sweets, and no cakes or biscuits at bed-time, to aid the start of caries. Caries is common in all classes. Spokes, in about 1,300 boys of the average age of thirteen at Haileybury College, only found about 3 per cent. with flawless dentition. Collated examinations of about half a million children in various European schools showed that 95 per cent. had some caries present. The importance of the subject is therefore not likely to be overestimated.

It was long ago pointed out that racial elements affected the predisposition to dental decay. A French writer, Magitot, in 1872 noted: "Les populations de la France se séparent au point de vue de la vie dentaire en deux grandes familles, la famille celtique, à individus petits et trapus et à dentition robuste; la famille kimrique, à individus grands, blonds, et dont l'organisation dentaire est defectueuse." This has later been confirmed for Dutch and German populations—the short, broad-faced Alpine (celtique) individuals only having about half the amount of dental defect present in the narrow-faced Teutonic (kimrique) individuals. Evidently the first point in the prevention of carie is to grow healthy teeth, by having a healthy mother and a well-nourished infancy, free from debilitating disease. Caries has, however, been much overlooked. It usually begins between the teeth, and so early that on first coming to school many children have already septic cavities in their teeth and tender mouths. Half of the six-year-old molars are diseased by the eighth birthday. Most of the pain of children is toothache or earache due to referred dental irritation, and tender mouths lead to bolted food. This and the constant absorption of toxic fluids like pus generally have serious results in the long run. Most of these children also have enlarged lymphatic glands from constant irritation.

Although Wallin in America believed in 1913 that psychological tests showed better mental performance in those with teeth well cared for, this is rather against common experience as regards other health conditions and the teeth. No clear case has yet been made out for caries being a weighty factor in defects during childhood, but then practically all children have carious teeth.

Dr. Hunter states that the experience of the London Fever Hospital among children is such that in a disease like scarlatina the septic complications—middle-ear suppuration, septic adenitis, albuminuria, gangrenous stomatitis, septic gastritis, and so on—are all more common and more severe where oral sepsis is marked.

Bad results of dental neglect are abundantly seen in later life. Any large hospital in an industrial district shows many cases of adult men with phthisis; there is usually a long history of stomach trouble, and a thoroughly septic mouth, with painful, foul, and useless stumps, which if not the actual cause are certainly powerful factors in the debility which has led to invalidism. Many cases of so-called rheumatism, and chronic and invaliding forms of obscure septic and painful joint diseases, frequently begin with oral sepsis, and some of these cases are relieved by dental treatment. There is no doubt about the extensive destruction of teeth going on quite early in life, affecting the individual's prospects, seriously damaging his wage-earning capacity, and even reducing some to a condition of semi-invalidism. Until quite recent years this was manifest in candidates for the teaching profession; now it is becoming uncommon except in those from country districts.

Public Provision.—Although repeatedly urged by dentists, the importance of school dentistry was scarcely realized in this country until the International Congress of School Hygiene at Nuremberg in 1904 made the work of Professor Jessen and the school dental clinic of the Municipality of Strassburg widely known. Dental caries then became recognized as an insidious, widespread, and damaging affection, requiring to be dealt with by public provision. There is indeed no way of dealing with money in the interests of public health which will return so enormous a gain to the population for the same relatively small expense as this matter of school dentistry and its following up to later life.

Deplorable results are often seen, which have cost the patients much at the hands of unregistered dentists, whose certificates are not recognized by many public bodies or by the Board of Education. The school dental clinic not only protects against this costly and inefficient practice, but if properly worked gives the greatest national results at least cost. Unfortunately, the full extent of the public provision required has not been everywhere appreciated, and here and there ideas of charitable service have crept in. A self-respecting people will at once stamp out any charity from their public service, and the school dental service will not attain its full economical development until every school child passes into the dental chair for examination—and, if necessary, treatment—once a year. Where so many are affected, dental examinations are almost a waste of time in school, and often lead to the stitch in time being omitted; it is for this reason that the routine annual visit to the clinic would be so valuable. Taking a long view, there should by this means be a considerable diminution of the amount of school dental work required in a few years, and it might then pay to revert to examination in the schoolroom. Efficient work in the school dental clinic ought also to be many times repaid by its saving effect not only on the national health, but also on the national health funds.

Educational Methods.—Apart from actual examination and treatment of the teeth, there is something to be done by educational methods. The prophylaxis or prevention of honeycombed and misplaced teeth is most important, whence the education of mothers to look after their own health is a rational step in the dental hygiene of the child. Further, the care of children in the earliest months, even before they have teeth, the avoidance of all causes of ill-nutrition, particularly rickets and diarrhœa, of the comforter and of oral sepsis, or any debilitating disease—all these are a part of the treatment.

The child must be taught not to permit food debris to remain on the teeth; he should have fibrous, hard, and stringy material requiring chewing at every meal. The use of the toothbrush and some tooth-powder should be made second nature.

The New York Health Authorities recommend a tooth-powder composed of precipitated chalk 16 parts, powdered Castile soap 4 parts, and powdered orris-root 1 part. This is an elegant preparation, but precipitated chalk is the basis of nearly every tooth-powder, and camphorated chalk is probably as good as any; indeed, even ordinary whitening may be used with advantage.

CHAPTER XIX

CLOTHING

Physiology of Dress.—A certain temperature of the body surface is necessary for the maintenance of health, and from this temperature (about 98·5° Fahr.) it scarcely varies a degree. This temperature is the result of the chemical processes going on in the body, the fuel for which is supplied by the food taken. In a temperate or cold climate, food being deficient, the body temperature would fall if there were no reserve of combustible material stored up in the tissues.

In order that the chemical changes which are comprised under the word *metabolism*, and which are the physical foundation of bodily energy and life, may be carried on, the regular removal of a definite quantity of heat is required from every square inch of skin. Much of this heat becomes latent and disappears in evaporation of perspiration. With very low temperatures of the surroundings a great excess of heat would be lost, and the prevention of this loss by clothing corresponds to a saving of food as fuel. Clothing should prevent as far as possible the chilling of the surface through loss of heat by radiation, which increases with the lowness of surrounding temperature, but should not interfere with that through evaporation, which rather diminishes with the low temperature. The clothing should be so loose that the film of air in contact with the skin is free to move over the surface. The material which is best for both summer and winter wear is wool, which should be worn next the skin, except in the few to whom it is irritating. The thickness and not the material should be altered with the temperature.

Amount of Clothing.—The amount of clothing for children should be sufficient to prevent any sensation of cold. Excessive clothing may increase a tendency to catch cold, by exciting perspiration, and especially because the extra clothing is often thrown off at irregular intervals. The effect of wearing a thick scarf round the neck is a well-known instance of this.

A deficient amount of clothing, especially in this variable English climate, is even more dangerous. Older children, by special feeding and by gradually increasing exposure in the sunshine, can be educated up to running and playing naked in the snow in a sunny Alpine climate. The attempt here, however, to harden young children to bear exposure to all kinds of cold with bare arms and legs, even when not engaged in active exercise, is calamitous; not a few are hardened out of the world, and those who survive may suffer in growth or constitution. Children lose heat easily, and during the cold winter months there is high child mortality.

Liebig first clearly explained the importance of clothing, saying, "Our clothing is, in reference to the temperature of the body, merely an equivalent for a certain amount of food." It will be easily understood, therefore, how in cold climates deficient clothing, like deficient food, may produce stunted growth, lay the foundation of disease, or bring latent disease into activity.

Although chilblains are an expression of imperfect nutrition, and chiefly seen in children, where this is one result of insufficient stimulating exercise, they are most prevalent in cold, badly ventilated residential institutions, and chiefly appear in damp and cold weather among those insufficiently clad.

Distribution of Clothing.—The clothing of children should be of such a character that the warmth resulting is uniformly distributed. No extra amount of chest protection will prevent bronchitis or pneumonia if there is chilling from cold legs or feet.

The fashionable habit, especially for young girls, of bare arms and legs, except in the height of summer, is reprehensible. Bare legs and white cotton socks may be the cause of much misery in later life, from contributing to the latent rheumatism so common in children. The *Punch* picture of the "Spartan Mother" covered in furs, with her scantily dressed, half-naked children, illustrates what is to be met in London streets as late as November.

The ideal dress for young girls is the popular gym costume (tunic, blouse, and knickers). Boys are usually fairly clothed, unless they have too much, e.g. as many as three waistcoats, and many children of the adenoid type are swathed up by careful mothers till they are actually made delicate, and then are dosed with cod-liver oil, when what they require is generally free activity and exercise. Damp weather has always to be provided for in England. Unless for temporary wear, waterproof garments are objectionable as preventing evaporation; this should be allowed for under a loose cape. Damp clothes require removal as soon as possible, otherwise evaporation may result in such serious loss of heat that a chill results. Cloakrooms require large provision for heat and ventilation beyond that for the rest of the school, although occasionally both are found omitted.

The changing of clothes at night-time is sometimes not completely done by girls, even as high as the Training Colleges, and in the lower classes of poor schools the tradition still is carried on of the small boy whose clothes had been "sewn on for the winter." In recent years underclothing seen at medical inspection has improved. Children should be especially warned of the dangers of fire in respect to clothing—of the necessity in case of

Fig. 29.—The Spartan Mother (from *Punch*, December 1913).
By Special Permission.

accident of lying down and of having a carpet or hearthrug tightly wrapped round them. Fireguards are a necessity in every room where children are free. Flannelette has had its scores of victims, and no material of this kind should be worn by children unless uninflammable. Celluloid collars or hair ornaments and combs have also dangers from easily catching fire.

Tight clothing of any kind is to be avoided; it interferes with ventilation, and also with free movements, and so hinders good exercise. Growing boys are often seen with excessively tight collars. Tight sleeves or skirts restrict movement of the limbs. Stockings are best held up with suspenders, not by garters, whose pressure tends to cold feet. Corsets are wholly objectionable on elementary school girls. Clothing generally should be slung from the shoulders and not tied round the waist.

Foot-gear.—Cold feet interfere with a child's comfort and distract its attention. Hindrances to circulation, such as the edge of too high a seat pressing the thigh behind the knee, by tight garters or tight boots, or even by sitting too long and too still, will dispose to the condition of cold feet. Boots are excessively heavy in many cases, although, on the other hand, thin boots are objectionable. Warming the classroom through the floor has great advantages, besides drying wet foot-gear. In some Amsterdam schools the wet shoes are dried on racks, the child meantime wearing list slippers. Some doctors have suggested clogs on account of cheapness and dryness, but these are wanting in elasticity and tend to cause flat-foot. High-heeled boots throw girls off their natural poise and produce a crippled, mincing gait. The shoes should be broad to give freedom to the toes, the greatest length being along the inner edge, and the wearer ought to be able to stand on tiptoe and exercise freely without trouble.

CHAPTER XX

CLEANLINESS

Personal hygiene, and the cleanliness which this connotes, are at the basis of a sanitary conscience, and the foundation of all rational and successful public health measures.

The reminiscence of courtly odours *de temps jadis*, said to have been awakened in a dowager of the ancient regime when the drains went wrong; and the removal of his own garments, to shake out the causes of the irritation, as noted by the veracious Mr. Pepys, have become distant and astonishing memories. Advances in sanitation in the middle of last century were essentially those of water-supply and good drainage, which are the first requisites of cleanliness.

Pediculosis.—In spite of teachers and fifty years of supervision by H.M. Inspectors of Schools, every elementary school at the beginning of the century had a large proportion of children visibly and obviously affected by vermin. One or two children could be found in most schools in a horrible state, and the writer recalls seeing, in the midst of an outdoor class at physical exercises, a well-grown girl, who in the sunshine appeared greyheaded from the multitude of nits. Vermin were allowed a prevalence that produced caked sores about the occiput, and numerous enlarged lymphatic glands at the back of the neck, conditions now but rarely seen, although even as late as 1907 Dr. Crowley, in his Bradford Report, makes a classification of children as "broken-out heads due to vermin." The doctor and the nurse in the school, however, have ameliorated all this.

These vermin are common to every race, and multiply at an extraordinary rate whenever they get the chance, so that they become the pest of armies in the field.

The head louse, *Pediculus capitis*, is different and smaller than the clothes louse, *Pediculus vestimenti*. A louse of a different genus, *Phthirius*, is found on the hair about the body.

The louse lays 100 or more eggs during its three or four weeks of adult life. Those of *P. capitis* are fixed as nits by a narrow base to the hairs, with the broad end, closed by a little rounded lid, towards the free end of the hair. The lid comes off the nit in about six or eight days, and when the small, active louse leaves the empty nit-shell, the latter, hitherto translucent, becomes a whitish speck on the hair. The animal moults three or four times, reaching maturity in two or three weeks. The infection is most difficult to get rid of, being evidently passed on from child to child. It is through caps and clothes, in the rubbing and contact of play, and at home even more than at school, that the transference is effected. Boys are fairly free, being short-haired; the majority of long-haired girls in elementary schools show some traces of nits. For most, regular use of a small-tooth comb is the only sure means of freedom. The wearing of the hair in a couple of plaits down the back appears to diminish materially the risks of contamination.

Treatment.—In a bad case the child's scalp requires soaking with paraffin oil, avoiding proximity to a naked light whilst doing this. Fortunately, although millions of children have been treated no accident from fire has been recorded. More thorough is an equal mixture of paraffin and olive oil kept on all night, the head being well wrapped up, and then washed with hot water and soft-soap in the morning, the nits being removed with a small-tooth comb and hot vinegar. More elegant preparations suggested are tincture of larkspur, or oil of sassafras, although the sassafras is strongly objected to by many on account of the smell in the classroom. If the mother sets about diligently cleaning her children's heads lice can be made to vanish in a week. Even allowing for bad housing, ill-lit rooms, and want of water, so far as head lice are concerned no mercy should be shown to parents who habitually send their children unclean to school, and usually the magistrates take this view. Depending on the district, between 5 to 10 per cent. of families are chronic, and three times as many occasional, offenders in this respect.

Clothes- or body-vermin are rarely seen on the skin, but the marks of scratching show, and if the clothes next the skin are turned outside in, vermin are often seen on the inner surface and eggs about the seams, particularly about the neck, and where the material is gathered together. Even when biting, these particular animals are said never to leave go of the cloth. They can be got rid of by hot bathing, and by baking the clothes or at least going slowly over the seams with a hot iron. In many cases having clothes lice it is hardly compatible with justice to place responsibility on the parents. Some have to live in houses where water has to be carried up many stairs, or where the sun never enters, so that if even the means of destroying the nits in the clothes could be got, it is too dark to see them properly. Most disinfectants are useless in practice against lice and nits, although soaking with petrol and allowing this to dry off kills them.

Cleansing Establishments, referred to later, should therefore now exist in connection with elementary schools.

Scabies.—A comparatively rare disease, but one which may crop up unexpectedly in connection with any one in schools, is scabies or the itch. It is usually confined to members of a few families who have hitherto been laxly treated, but who should be effectively handled by isolation until they and their belongings are free from the parasite. In Aberdeen all are removed to the cleansing station, the house and its contents disinfected, the family cleansed, and again given a clean start in life. The continued existence of such families in a district is an index of sanitary inefficiency.

The itch is due to a mite, one-fiftieth of an inch long, just visible to the naked eye. It burrows slantingly into the skin, laying its eggs at the bottom. The animal and its surroundings cause much irritation, with scratching. The usual appearance is of papules or pustules between the fingers, about the web of the thumb, the wrist and lower forearm. The disease may be mistaken for eczema, or put down to irritation from soap or washing soda, and may then get quite severe. The use of sulphur ointment, and sterilizing or baking the clothes, will readily put an end to it; but if the environment is not also cleansed relapses are certain. Second-hand clothes are generally blamed for playing a considerable part in disseminating vermin troubles, and possibly the cloakroom plays a bigger part in school than the classroom.

Ringworm.—In the majority of cases, except in residential establishments, ringworm is a disease of little importance. There are several varieties, due to the growth of various fungi about the roots of the hair and in the hairs themselves.

The commonest kind is the *small spored ringworm*, due to a fungus called *microsporon Audouini*. The infection appears to be commoner in the younger school children. The short-haired and cleanest boys appear to have vulnerable scalps. Most cases tend to spontaneous cure; but many last till puberty, after which some change causes it to die out. The first appearance is a small reddish spot, the hairs break off short and leave a bald centre, covered with fine silvery scales, and with a reddish papular edge. Between the nails of finger and thumb half a dozen hair stumps can often be plucked easily at once. The stumps have a silvery white sheath on the lower part. If laid in chloroform on a microscope slide, on evaporation this whiteness is marked; if then mounted in a weak solution of potash, the microscope shows the surface of the hair-stump eroded, and the hair covered or filled with small circular spores.

In another form, the large spored or "black dot" ringworm, the stumps break off just flush with the surface, showing as small black dots. When one is removed by epilation forceps it is usually much curled, and on microscopic examination, as described above, instead of small spores the larger spores of the fungus are seen arranged in rows, looking square and jointed like a ladder. This form, *megalosporon* or *tricophyton tonsurans*, is not very infectious, but is very resistant to treatment and slower in disappearing with age, persisting sometimes to sixteen or seventeen. It is often missed from bald spots—the usual appearance in the commoner variety of microsporon—being very rare in this variety. It is commonly found on animals, but does not occur once in twenty cases in children.

Ringworm acts in many ways like one of the epidemic diseases, and a careful study of its mode of spread would be of great value. Epidemic outbursts occasionally occur in school, but chronic cases are very common where the hair grows on again, or where it has never been completely shed at any part, and the child is merely thought to have a scurfy head. Indeed, the majority of scurfy heads in school children are really chronic ringworm cases. When once well established the various ways of treatment, apart from X-radiation, are finally scarcely more efficacious than feeding the child up and leaving the disease to run its course, as its persistence generally wins the day, ultimately, however, to disappear. The rapid method of cure is by epilation with Röntgen rays. The child's head is exposed to a definite dose of rays: the hair subsequently falls, bringing away the fungus with it. If during this time reinfection is prevented by the use of antiseptics, the child is cured in about six weeks. From careless or inexperienced workers a good many unsatisfactory results follow. Irradiation does not kill the fungus, so that without precautions children and their shed hairs are most infectious in the month just after treatment.

As regards school attendance, it will be sufficient if children with ringworm keep the hair short cropped, use ointment or antiseptic lotions daily, and attend school wearing close-fitting waterproof caps. They should not be allowed to mix with the others at play, and should be detained ten minutes on dismissal. The usual rule, however, is to exclude the child whilst ringworm can be detected by the nurse; if this is done the exclusion should be rigorous, and the school nurse or doctor alone be allowed to pass the child back to school. Medical certificates of freedom are not reliable without microscopical examination.

Mistakes are often made by laymen as to ringworm. *Alopecia areata* is a non-contagious affection where smooth, white, shiny, bald patches may be taken for ringworm. Scars and marks of injuries on the scalp, or patches of scaly roughness seen on the faces of badly nourished children in rough weather have at times led to their exclusion as ringworm cases.

Favus.—This is a disease also due to a fungus, known as *Achorion Schonleinii*. It is more obstinate than ringworm, and before the introduction of irradiation as treatment was almost incurable. Cure sometimes follows improved nutrition, but the disease may persist through adult life. Fortunately it is not very infectious. A boy with favus, the only one in the countryside, was watched in a school of 1,200 children for three years, without any second case being seen and no special precautions having been taken. In favus the affected hairs contain *hyphæ* as hollow tubules which can be demonstrated penetrating the length of the hair. By washing with ether and, whilst drying, mounting in a drop of Canada balsam, the microscope shows the favus tubules as characteristic black air-filled rods in the length of the hair, here and there branching dichotomously. A hair with some secretion about it, if mounted in potash, shows masses of short jointed cells like knuckle-bones as a collar about the outer end of the hair sheath. A mass of fungus and exudation grows round the openings of hair follicles to form the yellowish favus cup, which, if undisturbed, may grow to large size. It usually, but not always, has a mousy odour. Favus occurs in the Northern and Scottish towns more commonly than in the South. In London it is almost confined to alien immigrants. Fortunately, it is more objectionable than common, and as every case can be cured by irradiation it ought not to be permitted to exist.

Cleansing Stations.—From the point of view of effecting cleanliness, cleansing stations, as at present established, are in many places comparatively inaccessible and only a very partial success. They are Public Health arrangements worked under the Children Act. The arrangements are clumsy, and ineffective except in the worst cases. Until cleansing arrangements are simple their effect must be low. At present they scarcely touch the real sources of the trouble.

The type of proceedings is under Section 122 (1) of the Children Act, which empowers an authorized person to examine any child in an elementary school, and if necessary give the parent notice to cleanse it in twenty-four hours. If this is not done, Section 122 (2) authorizes the child's removal to suitable premises and detention till cleansed; if a repetition of the cleansing is necessary, Section 122 (4) renders the parent liable to a fine of ten shillings.

The school nurse therefore visits a school and examines the children, sending to the parents, in a closed envelope, warning and suitable instructions as to cleansing any whom she finds need it. If no amelioration results a stronger notice is sent, and notice of arrangements having been made for the child's voluntary attendance at a cleansing station. In the case of this being neglected, then a statutory notice under the Act is served, and failing cleansing the nurse takes the child to the cleansing station and has it cleansed. This looks well on paper, but in practice fails to cleanse probably four-fifths of children with traces of vermin.

Such a station should be for children only, and there should be a separate waiting-room, a bathroom, and sterilizing-room for the clothes. Either a large sterilizing chamber is used, or in small centres a simple clothes disinfector consisting of a chamber like that of a copper for domestic clothes washing. This is jacketed round by another chamber, in the lower part of which water can be boiled, and from this steam, entering the sterilizer in which the clothes are hung, destroys all life in about ten minutes. The steam enters through a three-way cock which can shut off the steam from the sterilizing chamber, then connecting this chamber with the outer air. It remains heated, and in another ten minutes the clothes are dried and ready for the child, who meanwhile has been thoroughly scrubbed with soft-soap and hot water in the bath. There need be no hesitation about cutting the hair of those being compulsorily cleansed, as the Act requires that the child, when it leaves the premises, must be free from all trace of vermin. It is also necessary, especially in cold weather, to see that children are detained long enough to cool off after their hot bath. During this time it would be a real advantage to stimulate each child by giving it a bun and cup of hot milk.

School Baths.—Public provision for bathing is not abundant, and the want of bathrooms exists in the majority of English houses. Indeed, very often with high rents the bathroom has to be utilized for storage or as a bedroom. Although there is a greater abundance of water, yet in respect to bathing facilities the population is behind, compared with Northern and Central European people. From Roman times, through the Middle Ages till the Thirty Years War, when all wood fuel was used up, hot baths were so popular in Central Europe that the regulations of many colleges and schools dwell on the dangers of cold water. For cleansing purposes the shower bath is now preferred, as it takes a tenth of the heat, a tenth of the water, and a fifth of the time required for an ordinary bath. There are manifest advantages in a clean skin, clean school air, and clean clothes; and nowadays the school bath is to be reckoned as a necessity from the sanitary point of view for every school of a thousand children, allowing each child to have one douche at least weekly, if they are to be kept free from lice.

All ideas of public baths to be used at certain hours for children have worked out unsatisfactory in practice. The cheapest school arrangements utilize the basement for shower baths. Swimming baths are taken as luxuries, and left out of consideration here. The shower bath as a school provision has been thoroughly worked out on the Continent, and it is easily managed and kept clean. It should provide bathing for at least twenty children simultaneously, and have two dressing-rooms, so that when the children of one batch are bathing the others may be dressing. A system of centres with simultaneous bathing for forty children is provided at Amsterdam. Each child stands in its own cell, placed against the wall of the large circular bathroom. This system of cells is the one generally adopted in England. In other countries the bathroom is generally lined with tiles, and has shallow troughs running along the floor; over these are suspended the sprays. The water is usually turned on the bathers at about 95° Fahr., and slowly brought down to 70° Fahr. and for older children to 65° Fah. In these bathrooms there are usually ten or a dozen cells at the ends for the older girls. Trouble has occasionally arisen on the Continent from religious cranks who have agitated against common bathing in the schools. Each child is provided with soap and towel and should wear a small apron—sometimes boys wear pants—and girls a bathing costume; but the simpler the dress the better. Long-haired girls must have caps. The drying of towels and costumes requires a large drying oven apart from the bathing machinery. Sixty children being bathed an hour, one bath just serves for a large school, and it is advisable that the bath should be under the same roof as the school, and that children should not be allowed to go home for at least half an hour after bathing.

The results of school baths are noticed in better and cleaner clothes, in increased self-respect, a distinct diminution of vermin, and the comparative absence of that restlessness they give rise to in school; also a marked improvement in the air condition and a tonic effect in sharpening up schoolwork.

Bathing is necessary for open-air school children, and indeed appears to be even more enjoyed by these than by the ordinary children. Another useful feature of bathing is that it means half an hour's relief to the child from the ordinary schoolwork, which, as the open-air school shows, is an undoubted benefit. The bathing under douche arrangements can be permitted to almost all children except certain heart cases. In the case of swimming there is much greater physical exertion, and therefore many heart and rheumatic cases should be excluded, also all cases excluded from physical exercises, and all children suffering from any kind of discharge. Some skin diseases and discharges of the eyes might theoretically cause contagion. Children who have, or who have had, aural discharge or with perforations of the drums should not go swimming without the greatest precaution, for in many cases relapses are started off afresh, and in several cases gross deafness has resulted to good swimmers.

Danger of Fumes.—Small bathing installations, as, for instance, a single slipper bath, are often supplied with hot water by a geyser heated by gas. Special attention must be paid to the ventilation, and the flue from the geyser must pass to the outside. Cases of sudden unconsciousness in school from inhalation of carbon monoxide gas, either from geyser fumes or from slow-combustion stoves, have occurred, and even deaths are on record from this cause. In such a case as a person becoming unconscious in a bathroom, doors and windows must be opened fully after the sufferer has been pulled out, and if necessary artificial respiration may be attempted for some time.

CHAPTER XXI

SCHOOL ACCIDENTS

The extreme utility of "First Aid" to the injured is shown by the popularity which the St. John's Ambulance lectures have attained. To teachers the knowledge of "First Aid" is particularly useful, for, in addition to the numerous accidents that occur in connection with school games, scholars may occasionally have fits or faints, or hæmorrhage. Panic, the result of ignorance, and even injury to health and limb, might often be prevented by the application of the simple rules of treatment which will be laid down in this chapter.

It must not be supposed that we are encouraging teachers to take upon themselves the sole treatment of serious cases, although we may have to describe the treatment of such cases in detail. But valuable time is frequently lost before a medical man arrives, and it is therefore highly important that the teacher should know what to do in the interval. Hence a not unsuitable heading for this chapter would be—"Until the doctor comes."

Fainting in schools which are ill-ventilated and overheated is not infrequent. The patient should be laid on his back, with his head low; all tight clothing should be removed from his neck; crowding round him should be avoided, and, if possible, he should be placed in a free current of air, near an open door. Do not attempt to pour anything down the throat while the patient remains unconscious, or he may thus be choked.

Fits may occur in school. In boys' schools, epileptic fits occur; in girls' schools, hysterical fits may also occur.

In epilepsy, during the convulsions, the patient should be laid gently on the floor, and prevented from biting his tongue, by inserting a cork between his teeth. All tight clothing should be removed, and no further attempt at active treatment made.

In hysteria, as a rule, the patient is not quite unconscious; she sobs considerably, and is evidently in a highly emotional condition. She will not allow the ball of her eye to be touched with the finger without flinching, unlike an epileptic patient. Hysterical patients should be removed from the school as soon as possible, as an example of this kind is likely to be copied. Their morbid condition should not be fed by over-attention or indulgence.

Suffocation is occasionally imminent from a marble or cherry stone, or similar substance, being held in the mouth, and then suddenly sucked down into the larynx. Such an accident is always serious, and a doctor should be immediately called, the messenger being instructed to tell him the nature of the accident in order that no time may be lost. In the meantime, the only safe measure is to put the finger to the back of the throat, in the hope that the foreign body may be reached. Even if it is not reached, vomiting is commonly excited, and this may dislodge it. The child should not be inverted until the doctor arrives, as, if it is not successful, the symptoms may be aggravated.

Apparent Drowning is not an infrequent accident, especially in country districts during half-holidays, and the teacher should instruct his scholars as to the plan to be followed in such an emergency.

The apparently drowned boy should be placed on the bank, his mouth cleansed from mud, etc., and his tongue drawn forward out of the mouth. It is seized by the fingers, in which a handkerchief is held to prevent the tongue slipping back. A folded coat should be placed under his head and shoulders, so as to give firm support. Next, the boy's arms should be grasped near the elbows by the operator, who stands over the boy, facing towards his feet. The arms should be drawn over the boy's head, and then pressed down firmly against the sides of his chest. This manipulation should be repeated regularly about fifteen times a minute, taking care not to perform the movements hurriedly. The upward movement expands the chest, while the pressure of the arms on the chest causes expulsion of air from it. In this way inspiration and expiration are imitated, and the natural process of respiration may in favourable cases be restored.

At the same time, other persons should secure warm and dry blankets and hot bottles, and should rub the legs steadily, so as to help the circulation and keep up the temperature of the body. The artificial respiration is, however, the most important point, and should not be intermitted until natural attempts at breathing occur, or until half an hour has elapsed without sign of recovery.

Foreign Bodies are occasionally pushed by enterprising children into the ear or nostril. In the latter case they can usually be seen and seized by a pair of tweezers, or hooked down by a fine wire loop. In the former case simple syringing with warm water will frequently wash out the foreign matter. If it is a pea, syringing is better omitted, as the pea may swell and thus become more firmly impacted.

Minute particles of dust, etc., frequently set up great irritation in the eye. Try and invert the upper eyelid, and then the speck can usually be seen, and removed with the corner of a pocket-handkerchief. If it cannot be seen, drop a little castor oil into the eye, keep the eye closed and immobile by means of a wet compress over it, and, if relief is not obtained in a few hours, seek further advice.

Concussion of the Brain.—A fall on the playground, most commonly on ice, especially if it bumps its head, may render a child unconscious for some minutes from concussion of the brain. The face is usually pale and cold, and on recovering consciousness the child feels sick or may vomit, which is not really a bad sign, as it shows that recovery is setting in. Some headache may last for the rest of the day, and some days of quiet rest will probably be required for recovery.

Wounds.—Where wounds or injuries exist the teacher is well advised to seek medical help at once. Wounds of varying degree and severity are very apt to occur in connection with school-life. Abrasions, where the skin is rubbed off, are sometimes very painful. In all cases the first thing to do is to wash off all dirt or grit with clean cold water, dry as well as possible by a gentle pressure with a clean handkerchief or linen cloth, bring the edges as near to the normal position as can be, apply a thick covering of boracic acid powder, place a clean linen pad over, and bandage up.

Hæmorrhage.—Bleeding comes from ruptured blood-vessels. When the wound oozes with dark blood the pressure of a linen pad will probably be sufficient, if firmly bandaged on. Arterial bleeding, which is bright scarlet, and pulsating or even in jets, requires very firm pressure on the bleeding part. If the teacher knows the course of the main blood-vessels in the limb, he may stop the hæmorrhage by pressing his thumb over the main artery higher up the limb; but as a rule, he will probably be more successful by trusting to a firm pad kept forcibly pressed over the wound itself.

An elevated position of the limb will help to stop bleeding from it, and a flexed position of the joint next above the wounded part has a similar effect. Thus, with a severe wound in the palm of the hand, apply a pad firmly over the wound, bend the elbow, and keep the whole arm raised.

If coughing or vomiting of blood occurs, keep the patient perfectly quiet and give nothing except ice to suck, and obtain medical aid at once. In bleeding from the nose, apply ice compresses to the nape of the neck, and syringe the nose out with iced water. If this does not answer, put some alum or tannin in the water to be injected into the nostril. If the bleeding still continues, a powder containing 30 grains of bromide of potassium may be given in water, and repeated in half an hour, if necessary. This seldom fails to stop the hæmorrhage.

Burns are apt to occur in connection with open fires or hot-water pipes. The best immediate application is probably a linen cloth soaked in a saturated solution of bicarbonate of soda, which very quickly relieves the pain and burning.

The following injuries are most apt to occur in connection with football, though occasionally from cricket or in the gymnasium:—

Fractures are recognized by inability to use the affected limb, shortening and alteration in its shape, and a crackling feeling when an attempt is made to move it. There is no urgency about treating a broken limb before the arrival of a surgeon. If it is necessary, however, to remove the patient indoors, the limb should first be secured in splints, and he should be carried on an improvised stretcher. Splints may be improvised by taking long pieces of a box lid or an umbrella; or for small children, brown paper folded up so as to be stiff and rigid.

Dislocations.—For school purposes dislocations, which are liable to be confused with fractures, may be regarded as such until the doctor comes. Sprains and contusions where the skin is not broken, but where there is swelling and pain, and where there may be blood effused under the skin, as in a black eye, are best treated by keeping the part at rest, and applying spirit and water or some cold evaporating lotion on a thin cloth, lightly bandaged on.

Serious accidents occasionally happen in cricket or football. A Prince of Wales lost his life at cricket, and in football a blow or kick over the abdomen may cause sudden death, or short of this complete collapse, which in some cases requires several weeks before recovery is complete.

Eye Injuries.—A wound of any kind about the eye may be serious, especially if the eyeball itself is scratched, pricked, or cut. In this case no delay must be allowed, as such a case may possibly end in blindness from sympathetic affection of the other eye.

CHAPTER XXII

ACUTE INFECTIOUS DISEASES

ACUTE infectious diseases are very important, both from the standpoint of those responsible for the public health and in the teacher's view, because no other diseases so seriously diminish the school attendance. Happily, the best means which the teacher can employ to bring the attendance to a maximum is by co-operating with the school medical officer's directions. It is a fundamental mistake for the former to imagine that he or she will improve the average attendance by hastening the return to school of children suffering, or suspected to be suffering, from slight attacks of illness, or by allowing the attendance of children at school from infected houses. Such children, if they attend school, whether in consequence of the pressure brought to bear upon their parents by the school attendance officer or the teacher, or in consequence of the carelessness of parents, may become a source of danger to classmates, and still may react by further reducing the average attendance.

Infection is Spread by Particulate Matter.—It has been proved for diphtheria and enteric or typhoid fever, and other less known infectious diseases, and although not yet demonstrated is equally certain for such common school complaints as measles, scarlet fever, mumps, and chicken-pox, that infection is transmitted from patient to patient by minute living particles or *germs*, which are the active agents causing the disease, the germs of each individual disease having special distinctive characters. In other words, these diseases "breed true," the germ of scarlet fever, for instance, not producing measles or *vice versâ*. These germs may be carried from scholar to scholar by direct contact, as when a girl convalescent from diphtheria kisses another girl, or when mucus from the throat of a child suffering from scarlet fever or whooping-cough is coughed into the face of another child. This is called **direct infection** or *contagion*. They may also be carried from scholar to scholar by **indirect infection**. Thus, a lead pencil is sucked by a healthy scholar, who two or three days later develops diphtheria. On inquiry it is found that another scholar had previously sucked the same pencil who had returned to school after a week or two weeks' absence from what was considered to be a "sore throat" or "ulcerated throat." Similarly, sweetstuffs are not infrequently passed from mouth to mouth. Other common sources of indirect infection arise. Thus, a child sickening with scarlet fever vomits in the schoolroom. Although this is cleaned up, some particles of infective material occasionally remain, become dry, and are then inhaled as dust raised by moving about the room, and give scarlet fever to other children. Or more rarely a child attending school from a house in which is a case of scarlet fever, or diphtheria, or whooping-cough, may carry in his clothes the infection to other children at school, although he himself remains well. As the essential method of communication of disease is the same in both direct and indirect infection, it is better to avoid the words *contagion* and *contagious* as likely to give rise to the erroneous notion that direct contact with a patient is necessary in order that infection may be transmitted.

Zymotic Diseases.—The acute diseases of importance in school are measles, whooping-cough diphtheria, and scarlet fever. Others of less importance are smallpox, chickenpox, mumps, German measles, more rarely cerebrospinal fever and anterior poliomyelitis (infantile palsy), and sometimes in residential schools typhoid fever.

Whooping-cough, mumps, and chickenpox are distinguished as non-notifiable, whilst the others are termed notifiable, in that the occurrence of cases of these latter diseases has to be notified to the Public Health Authority. These acute diseases are also often referred to in a general way as zymotic diseases. They have certain features in common. They are due to living infection conveyed from one person to another almost directly, and usually, except in rare cases, the radius of infection is not more than a yard or two. In some of the diseases, like diphtheria, as has already been stated, the infection can be separated and examined; in others, such as measles or scarlatina, its existence is perfectly evident, but it has not yet been isolated.

Each of these diseases runs a definite course; there is the conveyance of infection into the body; then follows a period of incubation during which certain changes occur, followed by the "invasion" of the disease which is shown by symptoms of illness; recovery takes place, after which there is immunity from any further illness due to this kind of infection. This immunity may be transient, as in diphtheria, or very lasting, as in measles or scarlatina.

Mechanism of an Attack of Infectious Disease.—It has been shown that for a healthy animal a certain minimal dose of infection is necessary to produce illness. If the individual is reduced in health the quantity required may be less. With a very slight dose of infection the disease does not develop into pronounced illness, but at the same time some changes take place which help later to resist a larger dose, and a partial immunity is gained. This explains, perhaps, why doctors and nurses and those who work in hospitals enjoy considerable freedom from infection.

With a larger dose of germs, and the usual conditions of health, the infection, once it has gained entrance, works vigorously, the germs multiply, and produce as a result of their activity certain poisonous bodies, *toxins*, just as the body produces its fatigue toxins. This process goes on for a time and the cells of the body react to these toxins and produce certain suitable cell ferments, called *antitoxins*, which neutralize the toxins, and may even react on the germs themselves, destroying them. This process is marked by setting up feverishness and illness, although that may be slight.

Thus, in measles there is a period of incubation of possibly nine days after infection, during which health appears perfect, then an invasion of catarrhal symptoms appears, often with nasal discharge and running eyes. The child at this stage is extremely infectious and becomes feverish and ill; about the twelfth to the fourteenth day from infection the rash appears; this state of health and the infectiousness disappear in a day or two. Later a branny desquamation occurs, and if the child is again exposed to infection it does not become ill. It has gained immunity to that particular disease. Sometimes this course is not followed: the measles is more violent, there is much bronchitis, and rarely the violence is so great that the child collapses and dies. The typical record, however, is—infection by the germs, an incubation period, invasion by the signs of illness, period of illness, recovery with immunity.

Immunity and how obtained.—This immunity is due to the body cells having been educated to dealing with this variety of germ, and to a stock of the particular protective ferments remaining in the body ready for any further invasion by that organism. The immunity varies in amount and duration from weeks to years, according to the disease and the condition of the individual constitution. For general public health it is important that as much immunity as possible should exist among the individuals of any community.

Immunity to these diseases may (1) exist naturally (as in the majority of people who do not contract scarlet fever when exposed as they are to the ordinary risks of infection), or (2) it may be acquired by going through the disease, as by practically all who suffer from measles or smallpox, or (3) it may be artificially imparted. This last is effected either by using a modified infection, as calf lymph against smallpox, or by using a vaccine of killed germs with their toxins, which stimulate the body cells to produce antitoxin, as is done for typhoid fever, influenza, and other diseases whose germs are known; or lastly, the antitoxin itself can be used, as in the case of diphtheria or tetanus, and if injected early enough and in sufficient dose even puts an end to the disease.

Natural immunity to diseases is very variable: thus almost every one who has not already had measles if exposed gets it, and the denser the population, and the more thorough intercommunication becomes, the earlier is the opportunity for infection. In the poorer parts of towns measles and whooping-cough are contracted on an average before five years of age; in socially better classes, where the child's "orbit" is restricted to its own home, or not more than one or two neighbouring families, measles is not common till children go out into a wider world at seven or eight. In isolated communities measles may be escaped for many years. Highlanders who come out of their remote glens and enter town life for the first time, coming, for example, as policemen, or joining the Army, very often within a few weeks go down with measles.

Scarlet Fever or, as it is latinized, **Scarlatina,** is a less common disease, and extends to later ages. Four-fifths of the community in towns either possess inborn immunity to it or have gradually acquired partial immunity, so that although probably at some time exposed, they escape actual illness from the usual chances of infection.

Diphtheria is also a disease which the majority escape, although no doubt exposed to risk from time to time.

Both these diseases are remarkable from the widespread prevalence of "carriers" of the germs, who suffer no inconvenience themselves, and may even serviceably help to distribute partial immunity through the community as well as actual disease.

Formerly many violent cases of these zymotics appeared. A child with a disease like scarlatina or measles had its resistance so lowered that it was also attacked by the various septic or dirt germs which produce suppuration, so that the tissues of the throat, or eyes, or ears became inflamed and perhaps were destroyed by such mixed infections. This class of case is getting rarer, as the bad cases are being constantly weeded out to go to hospital, or as cleanliness is more prevalent. Sanitation also tends to prevent massive infection by large doses of the germs, and all the commoner zymotics seem to be getting milder.

Beginnings of Epidemics.—In school it is important to be on the outlook for the first case of these diseases, for as seen in the school they may be easily missed. A daily examination by the doctor, as actually practised in America, would not be worth the cost. To-day a colleague tells me of his daughter, aged nine, thoroughly examined one afternoon this week. Having told the school doctor that she had had a bad cold for two days, she was directed to have her tonsils painted. On looking into her mouth her father was able to predict a measles rash in a few hours. The child had been three days at school in the most infectious period of the disease, had herself complained to the doctor of the typical symptoms, and been carefully examined, but the disease was missed.

Measles.—This is the commonest school disease in the infant department, and in towns is of little importance in other departments. It is almost certain to be missed in the first case in a district. The symptoms begin about the ninth day after infection like a cold in the head, but the eyes appear more glassy or watery than is usual with colds. In any case a young child with a cold should not be in school. In this stage measles is intensely contagious, and the child should be sent home at once, the parents being warned. Three or four days after the commencement of the coryza, if carefully looked for, small dark-red but glistening papules, the so-called Koplik's spots, can be seen on the mucous surfaces in the mouth, then in a few hours the rash appears. It begins as blotchy bluish-red spots in crescentic crenate arrangement about the face. This is the usual time when the child feels ill and when the disease is first discovered, but by this time the worst of the infectiousness is over, and probably in a day or two it goes with the vanishing of the rash, although there is branny desquamation for some time later.

Rubella, Rötheln, or German measles, has a somewhat similar rash, but which may be as red as a scarlet fever rash; it has no preceding cold, although there may be some sore throat or tender cervical glands. A first case may be mistaken for scarlatina, but fortunately it is usually a trivial and non-fatal disease.

Scarlet fever, or scarlatina, has been so mild for many years that it is frequently missed till the child is found peeling in school. These peeling cases, when not complicated by discharges, scarcely ever give rise to infection in the school. The usual time of onset is two to five days after infection, and the attack begins with sudden illness, headache, giddiness, vomiting, or what is called a bilious attack. The child most commonly has a sore throat, hot dry skin, and very rapid pulse. The scarlatinal rash generally shows by next day, about the front of the chest and wrists, as a fine scarlet rash, which in severe cases shows small straw-coloured vesicles the size of a pinhead. In a day or two the rash fades, and some weeks later the skin peels, coming off about the hands and feet in large papery scales. When scarlatina is prevalent, every sore throat is to be taken for school purposes as scarlatinal, until decided otherwise by the doctor, and, indeed, numerous sore throats in a district may appear as precursors of unrecognized scarlatinal or diphtheritic outbreaks, before the typical cases show themselves.

Diphtheria.—This is a very elusive disease, and should be suspected if an infant scholar has a sore throat or tonsilitis, especially if the cervical lymphatic glands are tender or enlarged. It has not usually the sudden onset of scarlatina, but there is often nasal watery discharge and the child looks pale and ill. Most children are very pale after diphtheria, and the examination of pale children often explains a short absence as due to diphtheria. "Carriers" are so common that on suspicion of diphtheria in a school it is a good rule to test all doubtful cases, that is, children who are pale or have nasal discharge, and look for the Klebs-Loeffler bacillus.

Bacteriological Test for Diphtheria.—In diphtheria the bacillus should be cultivated from the throat or nasal secretions. A long platinum wire with a small loop at the end is used to remove some nasal mucus, and this is directly streaked down one margin of a surface of blood serum solidified on the slope in a test-tube. The wire is then disinfected in a spirit flame, allowed to cool, and secretion from the crypts or surface of the tonsil similarly taken and streaked along the other margin. The tube is labelled with the name, covered, and incubated for eighteen hours, when it is examined for colonies. The colonies of the Klebs-Loeffler bacillus appear as minute opaque, whitish circular discs, which look darker in the centre when looked at by transmitted light.

Material from a colony is removed by a wire loop and smeared on a glass slide, in the form of a thin film, dried, and stained with methylene blue solution ; at the same time a second specimen is stained as a control with Neisser's stains, which show diphtheria germs as brown rods dotted with three or more blue "spores." Toluidin blue as a single stain has been more generally used of late years. As a rule

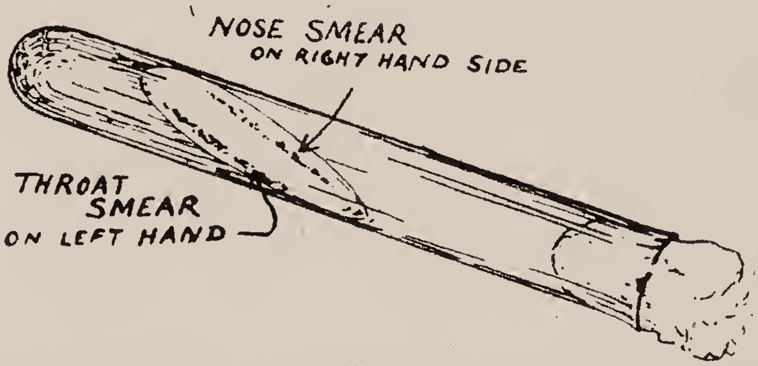


FIG. 30.—Cultures from throat and nose, made on a systematic plan.

there is little doubt about the nature of the micro-organisms found. Often several carriers are found in a school class, and on excluding them diphtheria cases may cease. On the other hand, where there has lately been an outbreak, since subsided, as many as one-third of the children may be carriers without there being any actual illness in the school, although a stranger coming from a district where there had been no diphtheria, to attend the school, would probably soon fail, and might suffer severely with the disease.

School and Infectious Disease.—These diseases appear most frequently and are most severe in the infants' departments. In the poorer districts many mild cases would be unknown but for the teachers notifying their absence from school. In one district where, after an outbreak, the course of scarlatina was carefully investigated, as it had occurred during some months, so that the inquiry did not affect the facts, it was found that one-fifth of the cases at school had only become known through notification by teachers; similarly, too, in diphtheria, school bacteriological inquiries add to the cases found.

During the school holidays this detection of mild cases by teachers and others does not take place, and without a knowledge of schoolwork, a superficial inspection or even statistical treatment of numbers of cases notified might give very misleading conclusions. The weekly notifications before, during, and after the holiday periods appear as if school attendance played a considerable part in disseminating these diseases. More careful study shows, however, that the fall does not coincide with the holiday period, but actually precedes it. Further study of the migration of children during holidays showed an average reduction in London of 20 per cent. of the child population. Taking this into account, and allowing for omission of cases notified by teachers and school officials, the so-called holiday effect on scarlatina or diphtheria appears non-existent in towns. Again, when holiday effect is looked for in the mortality curves of scarlatina or diphtheria, there is no trace, although it may be seen in the mortality curve of measles.

It is interesting, too, that there is a reduction in these infectious notifications during scheduling when the school attendance officials are busy with clerical work.

In country districts, where children with slight immunity attend from a wide area, disease may be disseminated by school to a greater extent, but the total school effect in usually distributing these diseases is probably small compared with ill-ventilated homes and crowded sleeping rooms. In the heaviest week of diphtheria in London during 1909, every case between three and fifteen years of age was investigated as regards school possibilities. Of the 99 cases, 2 were ultimately found not to be diphtheria; 38 did not attend school; for 29 there had been no other cases in the department during the year; in 10 no cases in the department within a month and none in the same class; in 15 there had been cases in the department, but none in the same class within the month; and in 5 cases, two of whom were sisters, cases had occurred in the same class within a month. So that in the week when diphtheria was at its worst, and presumably there was the greatest

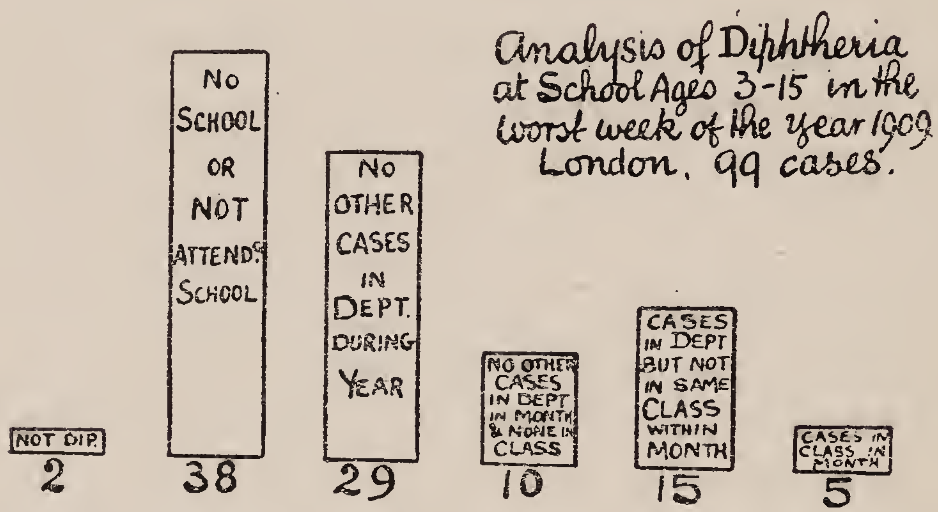


FIG. 31.—Diphtheria. The high degree of out-of-school infection in a city.

risk of school infection, not more than 5 per cent. of the cases of children of school age was traceable to this cause. For large cities it is improbable that school infection plays any part in more than 10 per cent. of the total cases of school age, yet if vigilance will prevent even a portion of these, or save any life, it is worth exercising.

Form of Class or School Outbreaks.—Where school infection plays a part, which it does when the proportion of children with some immunity is low, the appearance of cases of disease takes place in one class chiefly. Thus, in measles the usual infant-school outbreak is the appearance of four or five cases, infected from the same source and all in one class. On the other hand, where there is considerable immunity in a population, and where the school infection is comparatively small compared with outside infection, the first cases of the disease appear scattered in different classes. In one outbreak of scarlatina the first 17 cases in a school were in 15 different classes. The first appearance of diphtheria, in a district free for years, was the admission to an infant school one Friday afternoon of a four-year-old girl. She was seen about an hour after by the writer, who happened to be inspecting, and was sent home as she looked ill and had an erythematous patchy rash. By Monday morning seven cases of diphtheria were known among the class in which she was placed, and several children died. This was a school outbreak in a district where there was no public immunity; in London, for instance, where diphtheria immunity has been high for twenty years, such an outbreak would not occur. Where by continual exercise of the means to be detailed presently the school influence in spreading measles is assiduously repressed, the appearance of measles in infant schools tends to take on the form of distribution found in diphtheria or scarlatina, scattered cases appearing in several classes.

Management of Scarlatina or Diphtheria Outbreaks.—A school outbreak would be suspected where several cases followed at a few days' interval in the same class, but even here they are often found to be coincident. In one outbreak, where each of 51 cases was investigated by the writer, the only three in which there were facts suggestive of school infection were cases who failed in the same school class on three successive days and were the cause of the investigation; and yet each was a clear case of separate outbreak and not of school infection.

In both these diseases a slight case of sore throat may be the link between two or more typical or severe cases, and it is sometimes possible to work out chains of infection where the part played by homes comes out strongly. When contacts and sufferers are analysed, the percentage of contacts of both boys and girls is the same, but except in infancy the percentage of sufferers is always greater among the girls, due, probably, not to their attractiveness to germs, but to their greater contact in the home compared with the boys. The incubation periods of scarlatina and diphtheria are two to five days, so that sufferers, or those coming from homes where there are sufferers, must be forthwith excluded, and the names sent at once to the school medical officer. In the case of diphtheria, "carriers" can often be detected, whilst with scarlatina he can analyse the symptoms of children who may appear to have only had trivial illness or one or two days of absence. Each case of even a day of absence during the preceding three weeks should be investigated.

Management of Measles Outbreaks.—Measles is the most common and interesting disease, probably one day to be as rare among children as smallpox. It was the study of measles which has made school closure as a sanitary measure as obsolete as quarantine. Formerly schools were closed for measles when attendance had fallen from 30 to 50 per cent., and as subsequent analysis shows, the apparent effect of closure in stopping the disease was quite illusory. Fortunately the immunity conferred by one attack of measles is, for practical public health purposes, permanent. Second attacks are rare.

Course of Measles Outbreaks.—If the children on admission to school are noted as to whether they have had measles or not, then in event of an outbreak the possible sufferers are also known. Most of the children in an infant class who have not had measles, although not ill, will already be infected when the existence of the disease is first recognized. The course of an outbreak is as follows: A child incubating measles becomes infectious, say, on the first day of the month, and begins infecting classmates; this goes on till the fourth day, by which time a rash appears, and the illness, then recognized, usually keeps him away. The children infected on the first to the fourth show no signs for nine days from infection. These begin in the period from the ninth till the thirteenth, the first signs being those of a slight cold, cough, sneezing, and watering of the eyes. These signs mostly begin on the ninth day after infection, and the child itself is now intensely infectious; in another four or five days, that is, from the fourteenth till the eighteenth of the month, the children become feverish and the rash comes out. They generally cease to attend school. This group of children constitutes the *first crop*. Certain children may still remain who were absent on the first three days of the month, when the original infectious case was present, or who somehow escaped infection then; but they will probably not escape infection by one of the first crop, who became infectious about the ninth, and so they, too, begin to sneeze and water at the eyes, and finally fail in attendance as the *second crop*, after the twenty-third of the month. Beyond this the outbreak in the class is usually at an end. But closure to prevent cases after the original case should have been from the first to the third of the month, when the majority were being infected; as when they were becoming ill about the fourteenth, they infected the rest two or three days previously, and any closure is then too late to prevent a case.

The chart illustrates an actual outbreak, with the daily notifications, and showing the date of closure for three weeks insisted on by the Sanitary Authority in spite of representations that such an order would not save a single case. Subsequently it was found that the last case, infected a fortnight previously, failed a day before the compulsory closure.

This series of events is clearest where measles appears first after a considerable period in an infant school. To start with, there is an infected child present before failing with measles; then twelve to fourteen days later a first crop

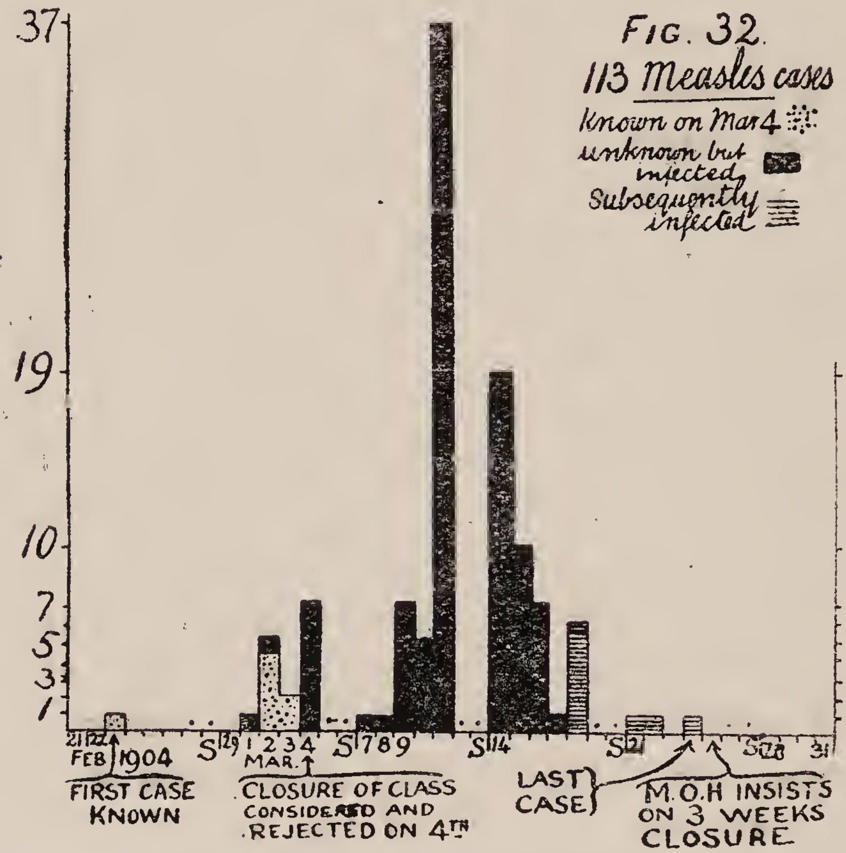


Fig. 32.—Measles outbreak in Hampstead.

fails, and about the twenty-third to the twenty-fifth day a smaller second crop brings the outbreak to an end.

If the first case is detected, then by excluding all unprotected children for four days after the ninth day the infected ones drop out, and the remaining ones escape infection. Even if practised assiduously there have to be many exclusions, and the inflammable material mounts up until perhaps two-fifths of the class have not had measles, when an uncontrollable outbreak may be expected. A very good rule when measles threatens is to exclude all five-year-olds for two weeks and all non-immune children in any infant class.

When several cases of measles have occurred in different classes of an infant school, and the district is known to be infected, exclusion of children is without useful effect. School closure is never called for, and in town schools, in other than infant departments, exclusion of contacts is quite unnecessary.

General Considerations.—The methods of school treatment which have been set out for measles, scarlatina, and diphtheria are applicable to other diseases. The common notifiable and non-notifiable diseases are therefore tabulated on pages 252 and 253 in regard to the limit of days to which incubation may extend, and the average is given in a separate column. A short note against each is given regarding attendance of sufferers, quarantine of those who are to be placed beyond risk, and attendance of children coming from homes where the disease exists.

In towns where large blocks of dwellings exist, those from model or trust dwellings only need to be regarded as possibly affected if they come from the same flat or self-contained tenement as the sufferer, whereas in houses let in lodgings, where rooms are sublet to separate families, the whole house should be considered affected, unless the separate flats are self-contained, i.e. have separate entrances and are provided with independent domestic and sanitary conveniences.

Other Subacute or Chronic Diseases.—There are certain other diseases and disorders which cannot strictly be included as acute fevers, but which are so infectious or contagious that they must be considered from the point of attendance. Any child who regularly coughs or spits should be excluded from school as possibly suffering from

Notifiable Diseases.

Disease.	Days' limit Incubation.	Average.	Period of Exclusion of Children suffering from Disease.	Quarantine.	Period of Exclusion of Children living in same House.
Smallpox (Variola)	10 to 14	12	Until after discharge from hospital or a certificate from the medical attendant	16	A fortnight after removal of patient to hospital (16 days for smallpox), or fortnight after date of disinfection of premises if the case was treated at home
Diphtheria	2 to 10	5	A fortnight after discharge from hospital, or, if treated at home, a fortnight after the premises are disinfected	12	
Scarlet Fever (Scarlatina)	2 to 8	4		10	
Erysipelas	—	—	Until after discharge from hospital or a certificate from the medical attendant	—	Need not be excluded unless this is requested by medical officer
Typhoid or Enteric	—	—		—	
Cerebro-spinal	—	—		—	
Acute Poliomyelitis	—	—		—	

Non-notifiable Diseases.

Disease.	Days' limit Incubation.	Average.	Period of Exclusion of Children suffering from Disease.	Quarantine	Period of Exclusion of Children living in same House.
*Measles (Morbilli)	10 to 14	10	At least three weeks	16	*Infants.*—All infants to be excluded until Monday following 14 days from the commencement of the last case *Seniors*.—If the child has had the disease it may attend, otherwise as above
German Measles (Rubella)	9 to 18	14	At least three weeks	20	
Mumps (Epidemic Parotitis)	14 to 23	21	One week from subsidence of swelling	24	Not to be excluded unless symptoms are present
Whooping Cough (Pertussis)	7 to 19	14	As long as there is violent coughing	21	*Infants.*—Three weeks from the commencement of the last case in the house *Seniors.*—May attend if they have had the disease, otherwise as above
Chickenpox (Varicella)	11 to 19	14	Two weeks, or until all scabs have fallen	20	

* Measles and German measles have (1915) been made notifiable as regards the first case in a house.

pulmonary tuberculosis, which is now a notifiable disease. Spittoons, common in Germany and America, are not allowable in a sanitary school.

Ringworm of the scalp and *favus* are chronic diseases in which there is not much risk of school infection, except in residential schools. The most infectious time is when a case has been submitted to irradiation and, about a fortnight later, the hairs are beginning to fall. All sufferers should be excluded until a certificate has been given of freedom from infection. Without microscopical examination mistakes are easy in chronic and doubtful cases. (See p. 222.)

Scabies, or "the itch," is generally a family disease. It is usually seen as pustules or papules about the wrists and hands, especially between the fingers. Any suspected case must be rigorously excluded for cleansing and cure. Children often relapse from insufficient cleansing. **Impetigo contagiosa** or **infectious eczema**, seen as pustules or sores about the face, is perhaps more common in the country than town; all sufferers must be excluded. White precipitate ointment should be used till cured, and any towels used in school removed. **Ophthalmia, blight, acute contagious conjunctivitis**, "pink eye," may run through a family, but should not be common in day-schools, towels then being the common source of infection. Excluding the affected children and shutting up the school towels for a week is usually sufficient. Trachoma is very rare in the elementary school, and any sufferer seen is almost always foreign born. It is a chronic inflammation of the eyelids and conjunctiva, which is likely to require long exclusion. In any doubt over these cases the school doctor must be consulted, the child being meanwhile excluded unless there is medical authority (family doctor) for its attendance.

Convalescence.—In the case of infectious diseases it is an advantage to the child itself that it should not have the strain of schoolwork for a considerable period. Formerly the Board of Education had an attendance allowance made for absence for infectious disease, known as Art. 101* of the Code, the removal of which elicited wide protest from those who had to do with public health. This premium on healthy education has never been reinstated, and the result is that children are often brought into school when quite unfit to benefit. Although infectivity may have passed, yet during and for a week or two subsequent to the acute illness the child's powers of nutrition and of resistance to disease are seriously impaired. It generally loses weight and its growth is arrested. Not only is it unfit, but it is likely to suffer some permanent mental loss from early resumption of work. Many other infections, either zymotics, or mere low forms of inflammation of the eyelids, middle ear, eruptions on the head and so forth, may follow these illnesses. The sequel of tuberculosis after measles is commonly spoken of. It is therefore evident that every allowance should be made, and the greatest caution exercised in receiving a child back to school; and provision should further be made for a medical examination in each case, not only to see that the child itself is fit, but to see also that it is not still harbouring infectious discharges, suspicious in scarlatina, and to be determined bacteriologically in diphtheria. Ere long these requirements will become financially important as a protection of the insurance funds now relating to adults.

School Closure and Disinfection.—Much has been made of school disinfection by purveyors of material for this purpose. Disinfection after cases of particular diseases is probably a waste of money when it goes beyond the use of soap and water in the schoolroom. For measles or whooping-cough no disinfection is required, save that, in the case of a child being sick, the sooner the offensive material is removed and soap and water applied the better.

In diphtheria or scarlatina there is no evidence that expenditure beyond soap and water gives any value proportionate to the outlay. Dr. J. J. Sykes termed school disinfection "a sanitary rite of considerable moral value." School closure should never be necessary; it is a confession of failure, a throwing up the sponge in the contest with disease. The following up of cases, especially of non-notifiable diseases, is thus lost.

Teachers and Infectious Disease.—Teachers come into consideration either from infection in their own family or in themselves. There is a certain amount of professional risk for the younger teachers, and sometimes it is probable that they have contracted the disease in school, but ten times as often the infection is caught beyond the school. It would be a safe rule to follow that teachers' absences due to disease prevailing at the time in their class should be allowed full pay, and the absence should not be counted against them, but doctors' bills or any other expenses they should pay themselves, as any other member of the public would have to do. Whooping-cough and diphtheria are probably the most commonly contracted from children, more rarely measles and mumps. Discharge from the eyelids and even itch or impetigo contagiosa occasionally appears to have been contracted through carelessness. Ringworm is never seen on the scalp in teachers, and only rarely on the face or forearm as a circular reddish patch, curable in a few days by tincture of iodine painted on, and not likely to cause absence from school. The acute conjunctivitis, when epidemic, may require absence for one or two weeks. Septic sore throats, diphtheria, and scarlatina or other zymotics require absence till a certificate can be furnished of freedom from infectivity and fitness to resume the strain of teaching. Where a teacher has a child ill at home with zymotic disease, she should forthwith take other lodgings, and in the case of measles or whooping-cough resume work, but in the case of scarlatina only after three days if in good health, and for diphtheria only after being swabbed free of the disease. A married woman who has a child at home ill with infectious disease should not attend school till it is well, but if it can go to hospital, then she may follow the same rules as for teachers who have taken lodgings.

CHAPTER XXIII

MEDICAL INSPECTION

Free access to medical advice and assistance concerning his work is as necessary to the teacher to enable him to carry it on with complete success as good ventilation and sanitary school buildings—access for the purpose, too, of preventing the spread of communicable diseases, and on many points relating to the physical and mental condition of the pupils.

Practical experience has convinced us that too much must not be expected of medical inspection at the school. Such inspection, however, will effect much if intelligently utilized, especially in the direction of examination of temporary absentees on their return to school. But even then, many cases, particularly of scarlet fever and diphtheria, may be missed. Thus a child returns after four days' absence, having had a slight attack of scarlet fever. The rash has disappeared, there is as yet no desquamation, and the child himself cannot give an exact account of his symptoms during the last four days. Or, after a week's interval, a child having had a slight attack of diphtheria returns to school. Unless a bacteriological examination of the throat is made, the medical inspector may easily be misled. The only safe rule, therefore, is when in doubt to continue exclusion until further medical inspection can be made at the patient's home, and the possibility of infection can be more definitely excluded.

The difficulties briefly indicated above can only be partially met under the present conditions of life, especially in towns. Parents earning under 30s. a week cannot be expected to call in a doctor for what they regard as trifling complaints. Even when a doctor is consulted, the parents may be obliged to call in one who gives advice and medicine for a fee of sixpence or a shilling, and who, to compensate for the smallness of the fee, must see such a number of patients that he cannot give sufficient attention to each. Still oftener, parents fall into the hands of druggists, who diagnose scarlet fever as nettle-rash, diphtheria as ulcerated sore throat, and so on. This state of matters, as pointed out by one of us,[1] "can only be remedied by having medical aid, to a certain extent, available for the labouring classes gratuitously in every district, without any implication of pauperism being involved in securing its advantages. . . ." This will involve a State Department of medical aid for free diagnosis, if not for treatment, in the first instance, at least. The sanitary and school authorities would greatly benefit by the adoption of such a State system of early medical aid, for no "parents could then plead that considerations of expense had prevented them from calling in medical aid, and one of the greatest advances in Public Health hitherto made would by this means be secured."

This paragraph, written at the opening of the century, still furnishes advice to be acted on, which will save both the national health and ultimately the national purse.

The Elementary Education (Administrative Provisions) Act, 1907, definitely established medical inspection of schools by including in Section 13, under the powers and duties of a local education authority, "the duty to provide for the medical inspection of children immediately before or at the time of, or as soon as possible after, their admission

[1] A. Newsholme, *Practitioner*, 1900, p. 192.

to a public elementary school, and on such other occasions as the Board of Education direct, and the power to make such arrangements as may be sanctioned by the Board of Education for attending to the health and physical condition of the children educated in public elementary schools. Provided that in any exercise of powers under this section the local education authority may encourage and assist the establishment or continuance of voluntary agencies and associate with itself representatives of voluntary associations for the purpose."

A system of medical inspection has been built up in accordance with the schedule issued by the Board of Education. The system is neither the best nor most economical, but it is the only one allowed. Each child has to be examined and returns made *seriatim* on the schedule. The schedule is as follows :—

Schedule of Medical Inspection.

I.—Name.................................. Date of Birth..........................

Address.............................. School ....

II.—Personal History :

(*a*) *Previous Illnesses of Child* (before admission).

Measles.	Whooping Cough.	Chicken Pox.	Scarlet Fever.	Diphtheria.	Other Illnesses.

(*b*) *Family Medical History* (if exceptional).

	I.	II.	III.	IV.
1. Date of Inspection				
2. Standard and regularity of attendance				
3. Age of child				
4. Clothing and footgear . . .				
III.—General Conditions.				
5. Height				
6. Weight				
7. Nutrition				
8. Cleanliness and condition of skin—				
Head				
Body				
IV.—Special Conditions.				
9. Teeth				
10. Nose and throat—				
Tonsils				
Adenoids				
Submax. and cervical glands .				
11. External eye diseases . . .				
12. Vision, R.				
,, L.				
13. Ear disease				
14. Hearing				
15. Speech				
16. Mental condition				
V.—Disease or Deformity.				
17. Heart and circulation . . .				
18. Lungs				
19. Nervous system				
20. Tuberculosis				
21. Rickets				
22. Deformities, spinal disease, etc. .				
23. Infectious or contagious disease .				
24. Other disease or defect . . .				
Medical Officer's initials				

General observations...

Directions to Parentor Teacher ....

The work of medical inspectors of schools largely consists in filling up answers to the numerous questions on these schedules, and completing forms for treatment, re-examination, and other objects arising out of them. There is little time for careful observation, and insufficient time to form a clear picture of each child as a whole, so that the doctor soon resigns himself to noting the isolated signs on cards. This does not really matter, however, for the routine work. It can be done satisfactorily at the rate of about twenty or more children a session, but this rate should not be exceeded. The work becomes poor if more than one session a day is regularly done.

The medical inspection, according to the Regulations, must take place during school hours, and, except in rare cases, on school premises. In order that the children may be seen in sufficient numbers, either teacher or nurse must give considerable help.

The usual routine work embraces children who enter school during the year, children of the age eight to nine, and children who will leave during the year. A certain number of children termed "specials" are examined at any age, on presentation by the teacher.

The teacher having noted the children for examination and filled in cards with name, date of birth, standard, regularity of attendance, and address of each child, the parents are notified of the day and hour of the doctor's visit in order that they may be present, and the majority of children do have a parent present, at the first examination at least.

The school nurse should previously examine the children as regards cleanliness of skin and the condition of clothes and footgear, also as regards traces of vermin or contagions. She should test the visual acuity of each eye, and weigh and measure the child without its shoes. When the parent comes up she can further determine the history as regards infectious diseases, of which measles is the only one of sufficient importance to be accurately informed about in regard to school attendance.

She prepares the child for the doctor's examination by loosing clothes above the waist. Finally, she notes the cases requiring treatment and fills up the cards in regard to this matter. Inspection is generally arranged for in classrooms, teachers' rooms, corridors, halls, and at times even in cloakrooms or lavatories. A favourite arrangement is to curtain off temporarily a corner of the hall; this at least has the merit of affording a reasonable amount of light and ventilation. A suitable school surgery should now be required as part of every school provision. It is needed for medical inspections and re-examinations, for nursing work in personal hygiene and cleanliness, and for the school treatment, which is the most efficient and economical way of managing nine-tenths of the cases needing treatment. A good water-supply, a roomy cupboard for stock of instruments, dressings, and other materials are wanted, and plenty of light. New American schools have such a room furnished as the "Nurse's Room."

The actual inspection requires some privacy and quiet. The persons who ought to be present are only those who can aid the doctor, namely, the parents, the teacher, and the school nurse. Except the School Inspectors, who should be notified of routine examinations for official visits, other persons are intruders on medical work. Without performing any useful purpose, time is wasted and one is conscious that routine is substituted, as it is frequently impossible to pursue an inquiry which sometimes borders on the confidential or to give proper advice with lay persons present. Apart from time wasted and the disturbance, my own experience is that irrelevant conversation is often particularly distracting to the examiner.

The nurse must see that the doctor is provided with all forms and cards required. Soap, water, and towels must be handy, and wooden spatulæ, so that there may be a fresh one for each child. Set the child in a good light facing the doctor, but remember that top light is particularly bad for throat or dental examination. The children, particularly entrants, have to be treated in a cheery, friendly way. One of these youngsters frightened to the extent of crying may disturb the whole afternoon.

Having filled in the schedule of inspection, the doctor has to decide on treatment. He must report every case which can be in any way improved by treatment, yet for many of these so reported, if seen in private practice, no one would think, in the case of enlarged tonsils, for instance, of suggesting operations. In such cases, quite properly, the tendency is, with experience, for the examiners to get slacker about recommending treatment, a course which appears in annual reports as a comparative improvement in conditions. Where in the first instance treatment is not done through a school surgery, there is greatly increased cost, for not one-tenth of the cases requiring treatment are such that the expensive services of a hospital are necessary. The methods for securing treatment are various. The most effective is the American system, where the doctor signs the child for treatment, and the method of arranging for this is left to the school nurse, the child's card standing on a file for the doctor's inspection until the child is presented to him as treated, and passed as fit.

With this arrangement urgent cases are treated at once, and serious cases have much pressure exerted, while trivial cases are advised, and so on, each case being treated individually according to its requirements.

A more complicated machinery, peculiar to this country, exists in some places, where cases are referred through a clerical staff to a school committee, known usually as the

Care Committee, who arrange the details for treatment. This has arisen out of the interpolation of voluntary associations mentioned in the Act. It often works slowly, and from the doctor's point of view rather unintelligently, in regard to the medical aspects of cases. Ultimately, however, although the machinery is clumsy, treatment is generally obtained and the case later submitted to the doctor for reinspection.

Simplicity, which is the mark of moral excellence in social endeavours, is badly wanted in the existing arrangements for medical inspection and treatment. Where treatment is required to satisfy public authorities, it should be freely offered, or at once additional and costly complexities are introduced. A wide view of the administration of the present school services suggests that the official requirements necessitate great efforts and cost in the remedying of comparatively trivial defects, whilst scanty opportunity is afforded, and little is being done, to seek out or remove the causes of these defects, or to directly improve the school and its work from the hygienic point of view.

PART II

APPARATUS

CHAPTER I

SITES AND BUILDINGS

The school sanitarian takes into account all that affects or tends to affect the health of those who work in the schools. On this account plans of new buildings or of any extensive alterations should have the approval of both school doctor and teacher. Architects tend to rule of thumb, just as much as doctors, and it is certainly an advantage to have their efforts supplemented from other points of view. The idea that the school doctor has merely to cover the statutory medical inspection must be at once dismissed, as that would be a failure in the chief part of his duty to the community. He should be there to do his share in protecting the health of those in school against whatever or whoever threatens it. The teacher, too, should prepare himself to be able to speak on such matters as the structure and furnishings of school, the details of educational apparatus and methods, the manners and customs of work, with a voice to be received not as a mere matter of opinion, but as given with scientific insight and clear judgment.

Site.—The site of a school is frequently a matter in which the educationist has not much choice. The architect will satisfy himself as to its value for building, but the choice is too often controlled by the prices demanded by property-owners. For the health of the community a public authority should be empowered to buy any property required for educational purposes either at the average rateable value of the previous ten years or the valuation under the Land Valuation Acts.

Sufficient area for children to develop in has not yet been provided anywhere and prevision is strangely lacking in this matter. As one travelled in the German Empire the first sign of a town was the large school building, beyond the advancing line of houses. Some American States, in plotting out the areas of towns, are said to have reserved one-tenth of the area for educational purposes. In the last Report (1914) of Victoria, the many small playgrounds are deplored, because, when the schools were set in Australia, there were plenty of playing-fields around, and the day was not foreseen when they would be all covered with houses.

The site area required by the Board of Education Regulations is a minimum of a quarter acre for two hundred children in elementary schools, but in secondary schools two acres for one hundred children, with playing fields in addition. These Regulations seem to overlook the fact that the time for education of motor activity is the elementary school age. The Secondary School Regulations throughout indirectly condemn the space minima, which in practice are maxima, prescribed for primary schools. A school is for teaching purposes; it is very different from a dwelling-house, and where choice is to be made the first place must be given to educational considerations. Too much weight should not be assigned to such things as ground air or dampness of site, for so long as the site is well drained and the construction of the school is satisfactory, elaborate consideration of subsoil is not needed. It is, however, important to secure an open situation, where there is plenty of air and the building will have good perflation and a wide exposure to skylight.

Schools do not require commanding frontages, and frontages to main roads should always be avoided whilst full accessibility of site is secured.

Street Traffic.—The necessity of escaping streams of traffic is very important for the younger children. Occasionally, schools giving on crowded thoroughfares have required a barrier rail for some yards along the kerb and each side of the gates to protect the thoughtless rush of children from the traffic of the roadway. Whilst "Safety first" is a good rule to be thought of by the doctor, this is entirely a matter for the teacher, who can do most by education, through warnings and pictures, to make children realize the dangers of illicit rides and street crossings.

Noise.—In towns, main roads and railways are the cause of much noise. Double windows cannot be used satisfactorily as protection, except in mechanically ventilated schools, where they are scarcely desirable. The best method is to plan schools isolated by the playgrounds and by intervening buildings. Even the use of the most noiseless roadways will only partially meet the street traffic problem. The play of other children may be disturbing. The proximity of machinery in engineering works, saw-mills, or carpet beating is against the suitability of a site. Whilst intermitting noises are distracting, constant noise, even from ventilating machinery, is nerve-straining, and attention becomes easily fatigued.

Smells.—Objectionable odours may become especially offensive in warm weather from dust heaps or stable manure, with the attendant fly nuisance. The neighbourhood of destructors, indiarubber or tarpaulin works, tanyards, soap, chemical, or gas works, and slaughter-houses or knackers' yards should be avoided in placing a school. With certain winds the smoke from near industrial chimneys may also cause trouble. Apart from smell, canal and river banks have their dangers in the proximity of boys' schools.

Buildings.—The impression obtained from an inspection of many hundreds of schools is that the Regulations necessitate a great expenditure of money which should be better utilized. The open-air school movement seems to show that progress has been held up by the massive buildings, which have soon outlived their usefulness. In England, unlike hotter countries, the orientation of the school is not a matter of vital importance. Probably the corners to the cardinal points of the compass will be quite satisfactory, but this can be modified to suit the site. The Regulations recommend an easterly rather than a southerly aspect. The position with respect to other buildings will be influenced by the lighting considerations mentioned later.

If a school must be built with all the solidity of a many storied house, which is scarcely necessary if sufficient space is provided, cellarage should be utilized in greater degree than at present. Such cellar space should not be deeply sunk and can be utilized for dining, bath, and play rooms, as well as for storage and administration purposes. This has the advantage, by raising them, of improving the natural lighting in the schoolrooms above.

Noise, already referred to in connection with the site, is a first consideration in schoolrooms, and every possible precaution should be used for its prevention. The noise of the city alone is a tax on nervous energy which must react on the growing child. Large central halls, formerly advocated and educationally useful, were often resonant, and high ceilings had the same result. The voice of the teacher suffers unduly, and tends to a strident, high-pitched quality, often ending in hoarseness or aphonia in the young teacher, and producing fatigue and inattention in the children.

Noise is an excuse for closed windows, equally, too, for repressing the natural exuberant self-expression of the children, a serious educational disadvantage.

Smooth wall surfaces of considerable extent cause echoes; so do wood-block floors laid on concrete. Steel laths for plastering are mentioned by some writers as contributing to noisiness. Double floors with deadening material, felt or asbestos cloth, can be made almost sound-proof. In one New York school absorbent felt has been placed on the ceiling and covered with muslin, on which decorated paper is pasted to give it a smooth surface. Hair felt is said to be liable to harbour vermin. One of the best methods is that of pugging the space between floor and ceiling with slag wool.

Fire-resisting floors should always be used in new schools and all doors made to open outwards. The infant departments are placed on the lowest teaching floor, and in many places slopes are used up to the infants' doors instead of steps. For the sake of cleanliness and good appearance inside walls should never be left either in rough or glazed bricks, but smoothly finished in plaster or cement. Rounded finish to the angles is seen in American and German schools, but this seems an unnecessary refinement and expense.

Water.—Each school requires to be provided with drinking-water. In our damp English climate insufficient water is drunk as a rule, although children require more water than adults, and the water is generally purer than in other lands. In America, for instance, in the southern parts, water may be pervaded by the hookworm, and in the northern parts and in Canada by typhoid fever germs, so that one may see enamelled labels fixed with wire on the taps in school: "This water is dangerous to drink, whatever any one may say." The only case of double supply in the writer's experience in this country was seen on inspecting the buildings of an industrial school closed a year previously, where a stream ran under the building and water was raised through an opening in the cellar for washing floors, separate drinking-water taps being provided from the company's mains. Some of the boys, however, drank from the stream in the cellars, with the result that the school had been closed, after over one hundred cases of typhoid fever among the inmates.

The dissemination of disease, such as diphtheria, is possible, although improbable, through school water-supplies, and the public drinking-cup in the school playground has been condemned. In America, where the public is more sensitive, paper drinking-cups seem to be provided freely by sanitary authorities, insurance societies, and as advertisements. From there also came the "crystal spring" drinking fountain, a little bubbling jet of water which can be drunk without a cup. It is sanitarily the best form, and has been extensively adopted abroad, although rarely seen in this country. There should be one fountain with jets for direct drinking to every hundred children, and although generally placed in the playground, a school corridor seems a better place.

Opportunity for washing the hands is required, separate from the cloakrooms; a place for each twenty-five children. This cleansing ought to be insisted on before school meals, although one still hears of school feeding centres where there is no kind of lavatory accommodation. Probably the most sanitary form is a spray not more than a couple of inches above the edge of a continuous trough, to avoid risk of splashing. Unless towels and soap are provided little washing is done. It is bad economy to provide the cheap, yellow, smelling resin soap generally seen in schools. This is often a cause of cracks and roughnesses of a patchy kind about the hands and face in early spring or damp, cold weather. The usual provision and renewal of towels is inadequate for cleanliness, and when ophthalmia breaks out in a school it is chiefly spread by the towels. They require renewal daily, one being supplied for every fifty children.

Disposal of Waste.—The sanitary provisions follow general rules which have been well stated by the Medical Officers of Schools' Association (Code of Rules, etc., 1915).

"1. All the **sanitary arrangements** of the school should be periodically inspected by a competent person, and any defect remedied as soon as possible.

"Amongst other essentials, the following points require special attention, viz.:—

"2. That all **foul-water drains** should be of iron-piping: they must be efficiently ventilated, and cut off from the sewer by a properly constructed disconnecting chamber.

"3. That all **soil pipes** be fixed outside the buildings: that they be efficiently ventilated and properly disconnected from the sewer.

"That the **joints** of all soil pipes and soil pipe branches be air- and water-tight.

"4. That the **closets** be of a type such as does not allow of the accumulation of sediment or of sewer gas. It is desirable that closets should be placed in detached or semi-detached buildings, efficiently ventilated, and not in the *basement* of the school.

"5. That no **drains** pass under the school buildings, unless this be absolutely unavoidable.

"6. That, in localities where there is no efficient drainage, **earth-closets** may be adopted, and should be placed in detached buildings (*vide* 4, *supra*).

"7. In exceptional cases, where a **cesspool** must exist, this should be placed no nearer to a dwelling-house than 50 yards. It must be efficiently ventilated, watertight, and so constructed as to permit of its being periodically emptied without nuisance.

"8. That all **waste pipes** be properly trapped, and both **waste** and **rainwater pipes** made to discharge over or into suitable gully pipes.

"9. That no fixed **dust-bins** be permitted, but that each day's accumulation of dust and refuse be removed to a distance in properly covered pails or metallic boxes, and efficiently dealt with.

"10. That all **drain gullies** be kept clear and flushed at regular intervals, as otherwise the water in the traps may dry up and drain air thus escape.

"11. That when any **sanitary repairs** or alterations become necessary, they should be carried out under skilled supervision, and, unless immediately required, during vacation time.

"12. That an accurate **plan** of the drainage and of the water and gas or electric light mains should be provided, and that a copy of this, kept up to date, should always be accessible."

The conveniences, wherever possible, should have separate wash down closets. The oldtime trough closets, if properly attended to, may be fairly satisfactory, but they should not be tolerated in new buildings.

The number of closets for elementary schools is laid down in the Regulations as—

Number of Children.	Closets for Girls.	Closets for Boys
Under 30	3	1
50	4	2
70	5	2
100	6	3
150	8	3
200	10	4
300	14	5
400	18	6

With boys' urinals in the proportion of 10 feet for 100 boys. Closets for secondary schools are one for every 15 girls up to 100, then one for every succeeding 20; one for every 25 boys, and one stall for every 15 boys.

Important hints about other varieties of closets, especially in country places, and the disposal of refuse and waste are contained in the L.G.B. Memorandum of 1913, which has been reprinted in Appendix to the Building Regulations for Elementary Schools.

Cloakrooms.—Cloakrooms are probably a common means of disseminating vermin. The Regulations require 4-feet gangways, but they should be 12 or 18 inches wider. Only one row of pegs should be allowed for cloaks and a higher row of long pegs for hats. They should be numbered and the allotted numbers rigidly adhered to. The lateral distance between pegs, even for boys, should not be less than 18 inches, that given in the Regulations for girls and infants. Abundant ventilation and warmth is wanted in these places. The use of wood, which harbours vermin, should be avoided. Iron and wire frames in which warm-water pipes can be placed are preferable.

The classroom as a school unit will be discussed on p. 336, after the factors which contribute to its hygiene have been separately considered.

CHAPTER II

THE NECESSITY FOR VENTILATION

The efficient ventilation of a school is the most important and generally the most difficult problem of school hygiene.

The usual conditions of civilized life, especially of urban life, involve many drawbacks. Persons leading a chiefly indoor life are never physically equal to those spending most of their time out-of-doors, and the continued massing together of people in large towns and the crowding of families in small, badly lighted, ill-ventilated houses involves the risk of producing a physically inferior race.

In the past there has been an unnecessary, and in fact mischievous, fear of fresh air. During the last few years this fear is happily disappearing. Much of the credit for the improved attitude towards ventilation is due to the crusade against tuberculosis, for the prevention and cure of which it is now known that an open-air life, both during hours of waking and sleeping, is indispensable. The chapter on the open air (p. 55) gives recent educational development of this idea.

The atmosphere in the open country has the following approximate composition :—

Oxygen	21 per cent.
Nitrogen and argon . . .	79 ,,
Carbon dioxide (CO_2) . . .	0·04 ,,

There are also varying quantities of watery vapour and traces of ammonia, ozone, and organic matter. The amount of ozone is greatest in country places and at the seaside.

In and near towns certain deleterious gases are found, including sulphur dioxide and sulphuretted hydrogen; but the main constituents do not perceptibly vary in amount. In the purest country air the amount of carbon dioxide is not above 0·035 per cent., and in the towns it is often about 0·04 per cent., and this difference is practically negligible.

The essential constituent of the atmosphere for all forms of life is oxygen, the nitrogen being inert and acting merely as a diluent for the oxygen. During all processes of combustion of organic matter—whether this takes place quickly as in a furnace, or slowly as in our bodies—carbon dioxide is formed by the combination of carbon with the atmospheric oxygen. If all living organisms constantly exhaled carbon dioxide, and it were not absorbed in some way, the atmosphere would in time contain an excess of it. Nature, however, has provided a means for the removal of any excess; all green plants contain a substance called chlorophyll, which has the power in sunlight of splitting up the carbon dioxide into carbon and oxygen, the carbon being utilized to build up the plant, and the oxygen being returned to the atmosphere.

The amount of moisture present varies with such circumstances as the temperature of the atmosphere, the presence or absence of sun, the position in a valley or on a hill, the amount of wind, and so on. Low-lying tropical swamps are laden with moisture; the slopes of high mountains are dry. On a wet day in summer the air contains a much greater amount of moisture than on a wet day in winter. The air also contains solid particles, consisting of mineral and organic matter blown about as dust, with which bacteria are frequently mixed. The chief harmful ingredients of air, both out-of-doors and in schools, are bacteria. In towns where dust and soot abound, the lungs of the inhabitants become very dark coloured, through the inhalation of these small particles. If the dust contained only particles of dead or inorganic matter, there would perhaps be no great danger from the inhalation, although it is certain that the inhalation of some kinds of dust—particularly that consisting of sharp, hard, mineral matter—is highly injurious. When, however, dust contains pathogenic bacteria the case is very different. The bacteria causing consumption are commonly present in the dust derived from the expectoration of people who are suffering from this disease. In the towns it is in the dry, dusty weather that attacks occur of what are known as common colds; and when we consider the constitution of town dust this is not surprising. Solid particles, however small they may be, are heavier than the air, so that when the air is still, dust and bacteria are present only in small quantity, and only for a few feet above the level of the ground. The higher we ascend the purer the air becomes. New York skyscraper hotels advertise rooms "above the dust and insect line." With a fairly strong wind the dust is blown about, and then is found at a considerable height. When rain occurs these small particles are washed out of the air, which then contains no dust and therefore no bacteria.

The Effect of Respiration.—Each time we inhale we take about 30 cubic inches (about three-quarters of a pint) of air into our lungs. The air enters the windpipe (trachea), passes down it and its branches (bronchi and bronchioles) into the infundibula or terminal air-cells of the lungs. These air-cells are lined with a very fine membrane, which easily permits of interchange of gases between the blood in the thin-walled blood-vessels around the air-cells and the air in these air-cells. If the air-cells were spread out the lining membrane would occupy a space of many square yards; there is therefore a very large area from which the blood-vessels can absorb oxygen and into which they can discharge carbon dioxide. The result of this interchange is that the expired air differs very markedly from the inspired air.

Expired air contains only about 17 per cent. of oxygen, or 4 per cent. less than fresh air; and although under moderate conditions of crowding the air in a schoolroom might be rebreathed many times, the percentage of oxygen would not fall to such an extent as to render air irrespirable from lack of oxygen or increase of carbon dioxide until long after it had become insanitary from other causes. In expired air the proportion of carbon dioxide is about a hundred times as great as that stated (0·04 per cent.) for outside air.

Extraneous Impurities in Rooms.—Besides the impurities caused by breathing, certain other impurities in relation to respiration must be considered here. These arise from two sources: the stoves used for heating purposes, and gas used for illumination. When stoves are used they are sometimes overheated to such an extent that the iron may be made red hot; under these circumstances carbon monoxide (CO) may pass into the room through the iron. This gas is inodorous, and therefore gives little warning of its presence. It is exceedingly dangerous, and, as stated on p. 229, may cause death even in small quantities. It combines with the hæmoglobin in the red corpuscles of the blood, and thus prevents the blood from carrying oxygen to the tissues. Short of fatal symptoms, carbon monoxide produces giddiness and headache, and impairment of the general health; in frequent exposure, even minute quantities produce great anæmia.

The products of combustion of coal gas are carbon dioxide (CO_2), water, and small quantities of sulphur dioxide

The last named is distinctly poisonous, and in the small quantities in which it is formed in a room by the burning of two or three flames may produce a feeling of tightness in the chest. Coal gas is frequently mixed with "carburetted water gas," containing 30 per cent. of carbon monoxide as against 6 or 7 per cent. in coal gas. With this mixture an escape of gas is fraught with serious dangers to life, compared with ordinary coal gas.

Alveolar Air.—It is not variation in the composition of the outer air which is of importance to the blood, but the composition of the air in contact with it through the walls of the alveoli or air-cells of the lungs. This alveolar air has a remarkably constant composition, with about 6 per cent. of carbon dioxide, a quantity only slightly increased by violent exercise. Haldane has shown that the carbonic acid content of the outer air does not affect the proportion in the alveoli, and that carbon dioxide in the air breathed, far beyond what is met with as respiratory impurity, is without determinable effect on the organism.

The oxygen of the air, too, can be diminished to 12 or 13 per cent. of an atmosphere, again far below what is ever met in any school problem, without determinable effect physiologically.

Smell.—Various odorous substances of a volatile nature, chiefly from decomposition of materials about the teeth, skin, or intestinal canal, from soiled clothes, or unwashed skin or feet, occur in school air. Their psychical effect is strong at first, but to those remaining in the air is soon scarcely noticeable. Probably these materials account for the theory that there is an effluvial or crowd poison in respired air, of a subtle and poisonous nature. It is too subtle, however, to isolate, and experimental evidence makes it doubtful that any such specific poisonous emanation exists.

Ozone has been advocated as a purifying agent for air, but in any strength which is not harmful to the mucous membranes it is too weak to do more than mask the smells.

Expired air is sterile as regards micro-organisms, although school air contains numerous germs, especially from the clothing of the younger children, and from droplets sprayed about in coughing, sniffing, and speaking. Infection through the expired air is limited to a comparatively short distance as a rule, and more due to this sprayed material than to genuinely air-borne germs.

Carbonic Acid Index.—As each individual gives off, on an average, 0·6 cubic feet of carbon dioxide hourly, and as it was assumed that air for breathing should not contain more than 6 parts in 10,000, the outer air containing 4 parts, it is evident that to keep air down to this level of carbon dioxide each individual would require 3,000 cubic feet of fresh air hourly. On this assumption the amount of carbon dioxide present became a valuable index of respiratory impurity, and its accurate quantitative determination of great importance.

It is now known that this carbonic acid index is only useful as an index of physiological deterioration of the air so long as the various factors of temperature, humidity, and movement of air vary proportionately. This is rarely the case. The value of accurate estimation of carbonic acid present has therefore decreased.

For regular investigations Haldane's apparatus is generally used, and is described in text-books of general hygiene. A simple comparative method, requiring no fine measurements beyond using a burette, modified from the method devised by Pettenkofer, can be improvised by those who only occasionally wish to determine the carbonic acid in school air in terms of that present outside. A Winchester quart bottle of whitish glass is filled with air in the playground or on the school roof. For this purpose a bicycle pump used for a few minutes will give an average sample. A few c.c.

of phenolphthalein solution is then run into the bottle to serve as an indicator; from a burette several c.c. of a weak baryta solution, of strength about 0·5 gram to the litre, are added till the solution is reddened; the stopper is then inserted into the Winchester and it is shaken till the colour goes; more baryta solution is again added and the bottle again shaken. When enough baryta solution has been added to permanently colour the fluid in the bottle, the number of c.c. baryta solution added from the burette can be taken as the standard for outside air. The numbers similarly found for air pumped in at different times or places in the school give their comparison with the outer air. With several Winchesters and a burette for each, and also a relay of boys to shake the bottles, determinations can be made for the changes in air every ten minutes if desired. The experimental errors in this method would be rejected by the analytical chemist, but it is accurate enough for the purpose and gives quite concordant results. It was the method used nearly twenty years ago in the observations on which Fig. 43 was based.

A method known as Angus Smith's, dependent on the largest bottle in which a half ounce of lime-water may be shaken without becoming milky, is not practically convenient.

So far the function of air as material to be breathed has been dealt with, and it may now be said that, generally speaking, any chemical alterations likely to be met in school air are hygienically unimportant.

Humidity and Temperature.—Expired air is also moister and warmer than the outer air, through a certain amount of water vapour and heat given off by the nasal and bronchial passages. It is important to attend to humidity, or the proportion of moisture in the air, and to its temperature. Corresponding to the carbonic acid produced by the processes of living there is also produced a quantity of heat and water. Just as the carbonic acid has to be got rid of, or it stops the supply of oxygen, so also the heat must be removed, or the chemical changes of metabolism are interfered with and serious symptoms appear. These symptoms of heat retention, resembling a kind of poisoning, include breathlessness, faintness, sweating, and feelings of exhaustion.

Flügge's Observations.—The cause of origin of these well-known symptoms was cleared up by Flügge, who used an air chamber, and showed that ventilatory discomfort was due to heat, moisture, and absence of movement of air in contact with the skin. A student breathing very foul and offensive air in the air chamber felt quite comfortable whilst his body outside it was exposed to the outer fresh air; when reversed, with his head in the outer air and his body exposed to the hot offensive air used up by respiration in the air chamber, the discomfort from want of ventilation was extreme, although breathing the pure air. This discomfort was relieved when the hot air of the experimental chamber, otherwise unaltered, was set in motion by an electric fan.

Ventilating Function of Air.—Air has therefore a function apart from respiration, which may be distinguished as ventilation. Whilst respiration is conducted through the lungs and embraces the chemical changes of carbonic acid for oxygen and loss of some aqueous vapour and heat, ventilation is mainly conducted through the skin, by which five-sixths or more of the heat and much aqueous vapour is dissipated. Neglecting the fractional portion of heat and aqueous vapour lost in expired air, the main channel of heat removal is by the air passing over the surface of the skin. The amount of ventilation in a room where the best possible air supply of 3,000 cubic feet hourly is obtained, is small compared with that got outside. The average rate of movement of winds in this country is 10 feet a second, or about 7 miles an hour. If the surface which a man exposes to this average wind is 6 feet by a foot and a half, that is, 9 square feet, then 90 cubic feet flow over him in a second, and 324,000 cubic feet in an hour; that is, 108 times as much as with the best indoors ventilation.

The quantity of heat the child has to part with as a result of the ordinary processes of living may be taken as 300 British Thermal Units an hour, the B.T.U. being the amount of heat required to raise a pound of water one degree Fahrenheit.

This heat can pass off in several ways, but it is chiefly in heating the layer of air next the skin, and in heat which becomes latent, large quantities disappearing as sensible heat in converting a certain amount of moisture of the skin into vapour which passes off in this film of air. The heating of this layer of air lightens it by causing it to expand, so that it tends to rise. The taking up of aqueous vapour does this still more, as the aqueous vapour displaces a part of the air and yet only weighs five-eighths as much. Still, the movements of the body and of the air itself are more important in keeping up fresh supplies than the lightening effects of heating and moistening which it undergoes through contact with the skin.

It is important that the skin itself is not cooled too much, or the abundant nerve supply to the skin causes discomfort from chill. Chilly feelings are largely a matter of habit and custom. The discomfort can be prevented by radiant heat falling on the skin from the surroundings, warmed walls and furniture, and by clothes preventing rapid loss of sensible heat. The great problem of school ventilation is to remove 300 B.T.U. of heat hourly from each child without materially or rapidly cooling the surface of its skin. There should therefore be sufficient heat taken up in slightly heating the moving film of air, and disappearing as latent heat of evaporation in the moisture taken up by this film. The film of air in contact with the skin, for efficient ventilation, must therefore be as cool as can be borne, and dry enough to just take up all the moisture the skin imparts; this requires it also to be in constant movement, or it would speedily be locally saturated and heated. Sufficient radiant heat must be supplied to keep the superficial nerve-endings in the skin from feeling chilled by lowering of temperature. This is only satisfactorily accomplished by cool, moving air, and by having a separate provision for the supply of radiant heat. It is possible now to understand the qualities of freshness associated with country air: they are coolness, moderate dryness, and movement. These are the qualities wanted in the schoolroom. Given these three qualities, the other matters of chemical composition are unimportant.

These qualities are estimated as—

(*a*) **Temperature.**—In English schools this is invariably measured by Fahrenheit scale. Actual measurements show that in this country children work best at temperatures between 55° Fahr. and 60° Fahr., although on the Continent rooms are generally hotter, and in America 68° to 70° Fahr. are prescribed, as in the New York and Boston Regulations.

(*b*) **Moisture.**—The moisture is easily calculated by means of wet and dry bulb thermometers. These are two ordinary thermometers fastened side by side upon a stand. Around the bulb of one a small piece of muslin about one and a half inches long is fastened and dips into a small vessel of water below the bulb. The muslin absorbs water and so moistens the bulb of the thermometer; the water evaporates from the bulb and thus abstracts heat from the bulb and mercury. The mercury in the wet bulb, being thus cooler than that in the dry bulb, registers a lower temperature. If the air in the room is dry, evaporation takes place quickly, and a correspondingly large amount of heat is absorbed from the mercury, and the difference between the two temperatures is considerable. If the air is already saturated with moisture, no evaporation can take place and no heat is abstracted from the mercury; the readings of the two thermometers are therefore identical. The nearer the reading of the wet bulb thermometer is to that of the dry bulb, the more moisture is present in the air.

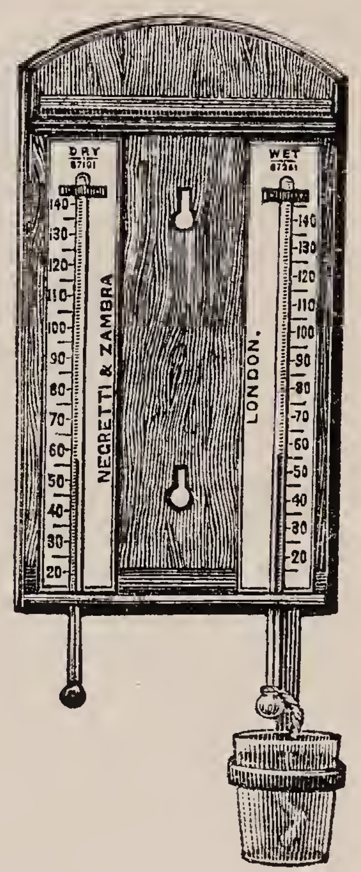


FIG. 33.—Dry and wet bulb thermometer.

As a rule there should be a difference of between four and five degrees Fahrenheit between the two thermometers.

The temperature of the room being kept between 56° Fahr. and 60° Fahr.—the best temperature—efficient ventilation will keep the reading of the wet bulb thermometer between 51° Fahr. and 55° Fahr.

The correct reading of the instrument is aided if it is hung by a cord and swung about in the air for some time before taking the reading.

Haldane has shown the great importance of temperature and humidity, and that for workers in deep mines, where these factors become considerable, continuous work is almost impracticable with a wet bulb temperature of 78° Fahr., and impossible when this reaches 88° or 89° Fahr.

(*c*) **Motion.**—Movement of the air is measured by an anemometer. This little instrument consists of a delicate fan with an index counter to show its revolutions, and is empirically graduated to read the rate of air current in feet per minute. In measuring the flow through an open window or doorway, the anemometer has to be systematically moved about over all parts of the opening equally, as the air current varies greatly in different parts of the opening and the instrument must be used to get an average reading for the whole. Greater accuracy is obtained if the mean of three separate readings is adopted.

CHAPTER III

NATURAL VENTILATION

It has already been seen that for ventilation a supply of cool, moderately humid, moving air is requisite. Air which has served its physiological purpose in respiration or ventilation is spoken of as vitiated, but this term should not be taken to connote the existence of any special poison, or impurity, or excess of carbon dioxide from respiration, but merely to refer to the function of the air, so that in this sense it is as justifiable to speak of hot air as vitiated as to use the term "vitiated" for air which has been modified by respiration.

In order to ventilate a room there must be provided (1) openings by which the air may enter; (2) openings by which the air may pass out; (3) a "head" or motive power which shall cause the air to enter the inlet openings and to pass out of the outlet openings. The adequacy of the supply of air for the purposes of ventilation depends upon the provision and due proportion of these three requisites. The quality of the air, as already seen in respect to its taking up heat and moisture, is also a requisite which until recent years was almost overlooked.

When special apparatus for producing motive power is used to propel or exhaust air, the system of ventilation thus obtained is termed *artificial*. When, on the other hand, advantage is taken of forces already existing in nature without modification to produce the head required for ventilation, the system is termed a *natural* one. The latter only is considered in this chapter.

Air obeys the physical laws governing gases. It expands on heating; contracts on cooling; hot air rises to the top of a room and cold air descends to the floor; in flowing through pipes it is retarded by bends producing eddies, and by the friction caused by contact with rough surfaces. The influence of friction upon the passage of air is insufficiently appreciated, the builder frequently being allowed to line the ventilating shaft with rough bricks without even dressing the mortar, leaving it to protrude into the shaft.

Natural ventilation is produced in three ways: by diffusion, by convection, and by perflation.

Diffusion is the property possessed by a gas whereby it tends to spread itself equally throughout a space in which it is confined. If a heavy gas, such as carbon dioxide, be placed in the bottom of a jar and in the top a light gas, such as hydrogen, the two gases will after a time completely mix, the proportion of each in every part of the jar becoming exactly the same. This process is, however, slow, and is one which, in all problems of ventilation, may be neglected.

Convection.—When fluids or gases, such as air or water, are exposed to heat, the small portions in contact with the source of heat are first warmed by conduction. These portions, being lighter, ascend through the overlying strata, and in passing give up their excess of heat by conduction to the particles with which they come in contact. This movement of heated particles is known as convection. Not only do the currents thus produced mix the air in the interior of rooms; they also cause an exchange between the outside and inside air. In an occupied room currents of air pass upwards from each person, first, because each person expires warm air, and secondly, because his body, being warmer than the external air, imparts heat to those particles in close proximity to him. As the warm air rises it warms the air above, and fresh air from the lower strata takes its place. When the warm air reaches the cold ceiling it imparts heat to it and becomes itself cooled. Being colder than the air just below it, it descends, and in descending becomes warmed. Were there no ventilation, interchange would go until the temperature of the ceiling, walls, and furniture approximated to that of the occupant

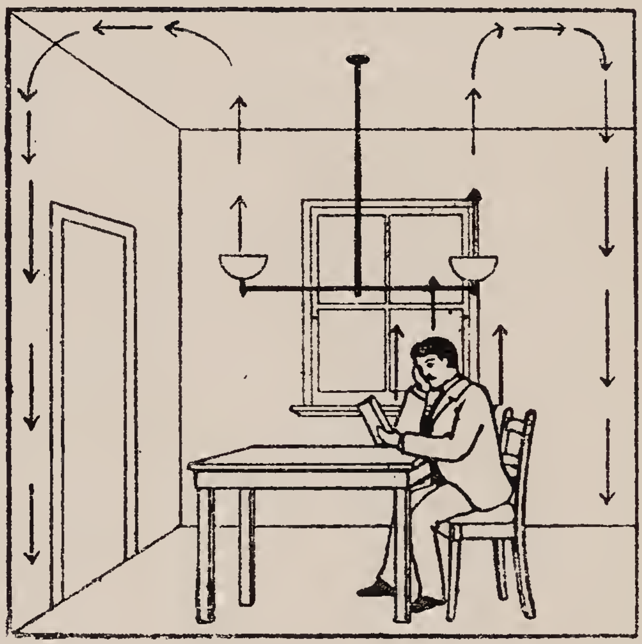


Fig. 34.—Showing convection currents from occupant of room and gas.

of the room. In an ordinary room the currents are upwards in the centre and downwards in the vicinity of the walls. The windows are generally cooler than the air in an occupied room, and therefore the air in their immediate neighbourhood is generally descending.

Soon the air in an occupied room becomes warmer than the external atmosphere, and convection currents are set up between the air inside and outside.

The velocity of exchange will depend upon (1) the difference between the temperatures of the inside and outside air, and (2) the difference between the height of the inlet and outlet. The amount of exchange will depend upon the velocity of exchange and the size of the openings.

The velocity is calculated by means of the following formula:—

$$V = \sqrt{2 g x (t^1 - t^2) a f} \text{ feet per second,}$$

where g is the acceleration of gravity and may be taken as 32.

x is the difference in height (in feet) between the inlet and outlet.

t^1 is the temperature of the air inside.

t^2 is the temperature of the air outside.

a is the coefficient of expansion of the air at t^2.

f is the coefficient of friction, and is generally assumed to be 0·75, although for a window this is probably excessive.

This formula is, however, only theoretically correct where there is an actual head caused by a shaft, chimney, or duct of height x, otherwise the height must be ignored, and just the temperature difference taken into account. If this is done, suppose an actual example: the temperature of the air in a school is 65° Fahr.; that of the outside air is 50° Fahr. The upper opening of a ventilating window is 10 feet from the floor and the lower 4. According to the formula this would work out about 2·9 feet as the velocity of exchange, but in practice, ignoring x, it works out as—

$$\sqrt{2 \times 32 \times 15 \times \tfrac{1}{509} \times \cdot 75} = 1\cdot 2 \text{ feet.}$$

The coefficient of expansion of gases, taken here as $\frac{1}{509}$, is for the temperature 50° Fahr.*

* Gases expand $\frac{1}{491}$ of their volume at 32° Fahr. (freezing-point) for every degree that they are heated. The absolute zero of temperature is therefore said to be 491° below freezing-point. In order to find the coefficient of expansion of air at any temperature, it is only necessary to add to 491 the difference between the observed temperature and 32, and place this number as the denominator of a fraction which has unity as

Hence the outlet in a natural system of ventilation should be placed as near the ceiling as possible, and windows which extend to the ceiling will be more efficient ventilators than those which do not. The working of all outlets or inlets by natural effects is very variable and entirely dependent on wind and temperature. Theoretically, the inlets should, when natural ventilation is in operation, be as low as possible. In practice, however, this plan cannot always be adopted; if the inlets are placed at the level of the floor the cold fresh air, being heavier than the warmer air, runs along the floor. The scholars' feet are therefore exposed to a constant current of cold air. For this reason arrangements are often made, as by Tobin's tube, to allow the air to enter about 5 feet from the floor; directly it enters the room it falls towards the floor, and thus mixing with the room air is warmed before reaching the floor.

The amount of fresh air entering a room depends upon two factors, (1) the velocity of the air entering or leaving, and (2) the size of the inlets and outlets.

In order to allow for contingencies, at least 72 square inches should be given, i.e. $\frac{1}{2}$ square foot for inlet and $\frac{1}{2}$ square foot for outlet, for each child. The outlets should be as near the ceiling as possible, and the inlets about 5 or 6 feet above the floor. As far as possible both inlets and outlets should be distributed over the walls of the schoolroom. Thus five inlets, each of 5 square feet, distribute fresh air more uniformly in a room than one inlet 25 square feet in area. This is subject to the general law that the friction of air passing through openings is inversely to the diameter of the openings.

the numerator. In the example the temperature 50° Fahr. is 18° above 32°. The coefficient of expansion of air at that temperature is thus—

$$\frac{1}{491 + 18} = \frac{1}{509}.$$

To minimize down draughts the opening of each inlet is guarded by a flap fastened to its bottom and allowed to fall forward, so that the incoming air is given an upward direction.

Perflation.—Although much time has been spent in describing the part which convection plays in ventilation, it is upon perflation or cross ventilation that an efficient natural system chiefly depends. Owing to convection currents the external atmosphere is nearly always in movement, producing winds. When the wind impinges against one side of a school, the whole of the elaborate arrangements for the ventilation of the room by convection may be upset, the openings upon the windward side becoming inlets, and those upon the leeward side outlets. With a mild breeze (about two miles an hour) perflation is insufficient to ventilate the room, and yet the operation of inlets and outlets of air for convection is disordered.

The ventilation of a school by perflation cannot be solely trusted, because the force and direction of the wind cannot be controlled. Arrangements should, however, be made by distributing openings as much as possible in every outside wall, so that in whatever direction the wind blows some of the openings will act as inlets and some as outlets. It is with a view to ventilation by perflation that it is advisable to have any subsidiary light on the right of the scholars (p. 338).

Ventilation by perflation is necessarily applicable only to a certain extent. If the wind is not of sufficient force perflation does not occur, for although the wind may enter the openings on one side, it does not possess sufficient impetus to drive the air in the room through the ventilating openings for exit of foul air on the opposite side of the room. For perfect perflation to take place the wind must be blowing at the rate of six miles an hour, and at right angles to the walls containing the openings. If the wind be not blowing at right angles to the wall containing the openings, a greater rapidity of current is necessary; and the more nearly parallel the direction of the wind is to the wall, the greater must be the rate of movement of the wind.

Thus, although under favourable circumstances a schoolroom can be ventilated by taking advantage of currents of air in the school and outside, in actual practice but little ventilation takes place during the greater number of the days in each year, owing to winds blowing in the wrong direction or with insufficient force, unless both windows and doors are kept open.

In recent years many schools have been planned so that perflation may be aided in all the rooms, by having large windows with hopper inlets on each side of the room. Still more recently, the logical outcome of the open-air school, are schoolrooms the whole of one side opening to verandas, and in some new schools in Derbyshire a run of clerestory windows is also provided on the other side, opening freely for cross-draughts.

From the preceding considerations it is clear that the *maximum bonum* in natural ventilation, unless both windows and doors are wide open, is the dilution of used with fresh air; while, as we shall see later (p. 311), the *maximum bonum* of artificial ventilation is the steady replacement of used by fresh air.

Hitherto no mention has been made of heating the schoolroom, and the effects of this upon natural ventilation. An open fireplace is a powerful aid to ventilation, and will be spoken of later. Some schools are warmed with hot-water pipes, employed solely for heating. These pipes, as well as open fireplaces, may, however, be made valuable adjuncts in ventilating a schoolroom.

In Fig. 35 the chimney has built alongside it separate flues* for carrying off foul air from each room. *A* is the smoke flue; as the hot smoke flows to the top of the chimney the independent vitiated air flues *B* become warmed and the air of them begins to flow upwards.

No mention has as yet been made of the actual construction of inlets and outlets. There should be several inlets and outlets. The actual number and size of the openings must be regulated by the number of children who will occupy each room, allowing half a square foot

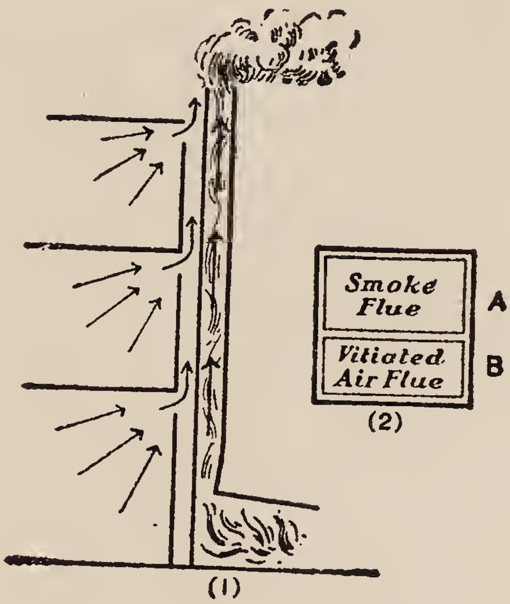


FIG. 35.—(1) Elevation; (2) section of double flue.

of sectional area of opening for inlet and the same amount for outlet for each child.

The simplest form of inlet or outlet is a hole through the wall at right angles to its surface. This must be lined with smooth cement to diminish friction for the incoming air and to aid cleansing. Its outer end is protected by a grating. The size of the inlet is gauged by the free

* From the diagram it may be inferred that there is only one vitiated air flue. In actual fact each vitiated air flue, like each smoke flue, must be carried up to the top of the chimney stack separately from all other flues if back currents are to be avoided.

air-space of the grating and not by the size of the entire aperture. The grating must be both safely fixed and easily movable, as it requires to be cleansed at frequent intervals and the accumulated dust removed.

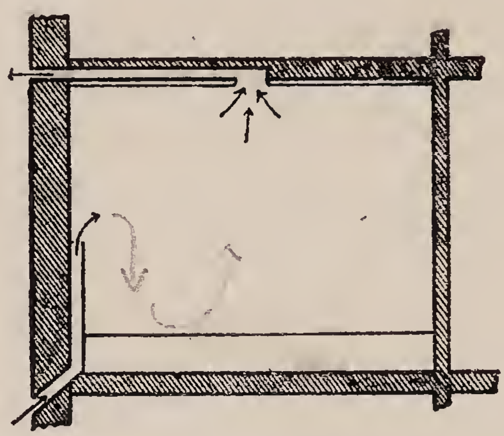


FIG. 36.—Tobin's tube and outlet ventilator through ceiling.

The inlet may have one of several contrivances at its inner end to direct the current of air upwards and across the room.

Special arrangements or apparatus for assisting ventilation are extremely common. The following are a few of the better-known forms :—

Tobin's Tubes.—These allow fresh air to be taken from at or below the level of the floor of the room and discharged into the room 5 to 7 feet above the floor. The cold fresh air, receiving by this means an upward direction, enters

FIG. 37.—Sheringham's valve.

the room and mixes with its impure air without causing much perceptible draught. The tube should be circular in section, and the angle between the external aperture and the vertical tube as obtuse as possible (Fig. 36).

As already indicated, Tobin's tubes are not always reliable, and likely to fail when wanted most, as on a hot summer day without much wind.

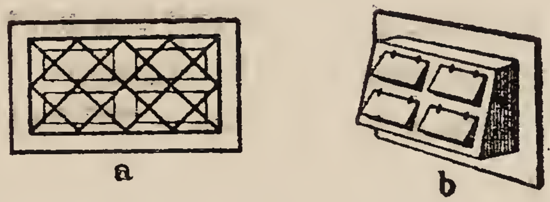


FIG. 38.—Boyle's mica flap outlet ventilator.
a, View from room ; *b*, view from chimney.

Sheringham's Valve is an arrangement by which the flow of air through the opening in the wall can be regulated at will (Fig. 37).

Boyle's Mica Flap is supposed to be useful in removing some of the foul air from the top of the room into the chimney (Fig. 38) ; but a better plan is to provide a separate foul air flue, as shown in Fig. 35.

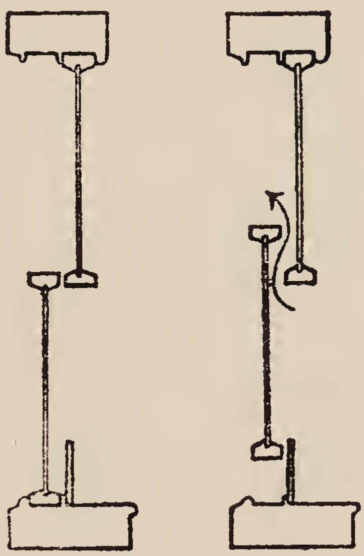


FIG. 39.—Hinckes-Bird window ventilator.

The Windows may have contrivances to allow the fresh air to enter in a certain direction ; for instance, if the bottom sash has placed under it a wooden guard about 2 inches high and the lower sash is brought down on to this, air enters the room with an upward direction between the sashes.

Many such contrivances are applicable rather to small rooms, such as teachers' rooms, with a certain amount of benefit, but the smaller the opening the greater must be the rate of flow, and a perceptible draught is felt if air is entering a room with a temperature 10° Fahr. below that of the room at the rate of more than 3 feet per second.

CHAPTER IV

WARMING OF SCHOOLS

It has been shown in the last chapter how impossible it is to provide efficient ventilation in a school by natural means. There is practically no satisfactory method of artificial ventilation which is not intimately connected with the particular method of warming employed. In some cases both functions are performed by the same mechanism, as happens, for example, when warmed fresh air is propelled into a room; in other instances advantage is taken of the heating arrangements to produce the "head" necessary for ventilation, as occurs when an open fire is used.

Until the subject of warming has been thoroughly examined, therefore, it will be convenient to postpone the consideration of artificial ventilation.

Heat is distributed in three different ways: (1) by conduction; (2) by convection; and (3) by radiation.

Conduction.—This is the method by which heat is transmitted through solid bodies. If one end of a copper rod be heated in the fire the other end will soon become hot. Copper is, therefore, said to be a good conductor of heat. If a glass rod, on the other hand, be so heated, the end which is in the fire may actually melt, yet the rod 2 or 3 inches from the fused end will be scarcely warm. Glass is, therefore, said to be a bad conductor of heat. Conduction is, again, exemplified in the different sensations experienced when the hand is alternately placed upon pieces of wood and metal, both of which are at the same temperature. The metal appears to be colder than the wood, because, being a good conductor, the metal abstracts heat from the hand and quickly passes it away from the surface in contact, whereas wood, being a poor conductor, does not readily transmit the heat abstracted from the hand away from the surface. In the warming of a room conduction plays a very minor part.

Convection is thus explained by Clerk Maxwell: "When the application of heat to a fluid causes it to expand . . . it is thereby rendered rarer than the neighbouring parts of the fluid; and if the fluid is at the same time acted on by gravity, it tends to form an upward current of the heated fluid, which is, of course, accompanied by a current of the more remote parts of the fluid in the opposite direction. The fluid is thus made to circulate, fresh portions of fluid are brought into the neighbourhood of the source of heat, and these, when heated, travel, carrying their heat with them into other regions. Such currents caused by the application of heat, and carrying their heat with them, are called convection currents. They play a most important part in natural phenomena by causing a much more rapid diffusion of heat than would take place by conduction alone in the same medium if restrained from moving. The actual diffusion of heat from one part of the fluid to another takes place, of course, by conduction; but on account of the motion of the fluid, the isothermal surfaces are so extended, and in some cases contorted, that their areas are greatly increased, while the distances between them are diminished, so that true conduction goes on much more rapidly than if the medium were at rest."

Radiation.—When a solid body, such as a piece of iron, is heated in a hot fire, it becomes white-hot and emits luminous rays. When removed from the fire the mass of iron soon presents a dull red colour, and finally is invisible in the dark. Long after it has ceased to be luminous it continues to give out rays, which can be easily felt as heat by the hand, or registered on a thermometer. The heat, like the light, is conveyed from the hot iron to the cooler hand by radiation. Heat rays resemble light rays in many respects. Heat rays pass through many substances, just as light rays pass through glass. Such substances are said to be diathermanous. A substance which is absolutely diathermanous allows the rays to pass through it without itself becoming heated. Air is not strictly diathermanous, but the amount of heat taken up by the air is so small that for practical purposes we may say that the air remains unaffected.

A schoolroom may be heated in three ways: (1) by means of a fire; (2) by means of hot pipes; and (3) by means of hot air.

1. **Heating by Means of a Fire.**—The usual method of heating small living-rooms in this country is by means of an open fire. The coal in burning becomes hotter than the room, and the heat, radiated from the hot coals, warms the furniture of the room. The heat acquired in this manner varies inversely as the square of the distance from the source: thus, if two pieces of furniture were placed 3 feet and 6 feet respectively from the fire, the amount of heat received by the latter would be $\frac{9}{36}$, or $\frac{1}{4}$ of that received by the former. As the furniture becomes warm, the molecules of air in contact with it are warmed and ascend, setting up convection currents. The whole of the products of combustion of the coal, together with much heated air, ascend the chimney and are lost to the room. It will thus be seen that the greater part of the heat produced by the combustion of the coal is lost; it is calculated that only about $\frac{1}{10}$ is available for heating the

room. Heating by an open fire is, therefore, extremely wasteful.

It is quite impracticable to heat a large schoolroom by such a fire, because, in order to have any appreciable effect upon the temperature of the room, the fire must be so large that the children in its immediate neighbourhood are scorched, whilst the opposite side of the room remains almost unwarmed. An open fire adds no products of combustion to the room, all these disappearing up the chimney. It, however, increases the dust in the room.

Stoves give more heat than open fires in relation to the fuel consumed. The closed stove is very popular abroad, but not in this country. The stove helps to set up convection currents and keep the air in movement. The danger of cast-iron stoves when overheated allowing carbon monoxide to pass in amounts which are insanitary has been referred to; in addition, any stove which presents a very hot surface to the air causes a feeling of dryness in the throat and lips.

2. **Heating by Means of Pipes.**—When pipes or heated air are used, the furnace which is the source of heat is not in the schoolroom, but generally in the basement; such methods are included under the term *central heating*.

The pipes may carry hot water or steam. The hot water may be under either high or low pressure. In a *low-pressure hot water system*, which, it must be insisted, is to be always recommended for school purposes, the water is heated in a boiler and thence circulates through the pipes. A comparatively large quantity of water is used, and the pipes are large, from 2 to 4 inches in diameter. The result is that a considerable time elapses before the pipes become hot, and once hot they take a long time to cool, because of the large volume of water heated. With high-pressure steam or water, smaller pipes are used, the heating can be more rapidly done, and equally the cooling is quicker. The room-heating is usually done by radiators, which, if any other system than low-pressure hot water is used, have to be enclosed, as their surfaces may be too hot to touch. These hot surfaces also produce the dry feeling in the air referred to in connection with stoves. This is said only to occur in air which has passed over surfaces heated above 160° Fahr. and to be due to the partial distillation of dust. It is not noticed with low-pressure hot water heating. Although vessels with water for evaporation are often used in connection with stoves or radiators, their effect appears to be psychical, as the amount of water evaporated is negligible.

A method of heating recently introduced into some Derbyshire schools, where there are extensive arrangements for opening up the sides of the classrooms, is by hot pipes laid under a 2½-inch thick concrete floor, which is thus maintained at a temperature of 75° to 80° Fahr.

The purpose of this added heating is to warm the walls of the building and the furniture, so that the skin surface of the children may not be chilled by excessive radiation to cold surroundings. At the same time heat has to be removed, largely as latent heat of evaporation, and also by the body warming the air in contact with the skin. The carriage of heat to the schoolrooms should therefore be kept separate from the air supply, and the air should be at a moderately low temperature. The danger of unventilated rooms to the health is that the air also gets heated by the stoves, radiators, or hot pipes, and thus, unless kept in constant movement, as by a fan, becomes physiologically impaired for heat removal, which is its function in ventilation.

3. **Heating by Means of Hot Air.**—This method still exists, but from what has been said in the previous paragraph it will be seen that ventilation by heated air may be

physiologically compared to giving a thirsty man salt water to drink. Heating should only be done when the temperature of the outside air falls below 45° or 50° Fahr.—it is then necessary to warm the air to about this temperature.

Moistening Air.—Where air is passed over radiators, or its temperature considerably raised before delivering it to the rooms, the relative humidity is lowered, so that it may have a drying effect. To obviate this it is often wetted as thoroughly as possible by damp screens before heating, or even after heating by jets or sprays of water; but it is difficult to make very humid. If too damp, moisture will be deposited on the windows or walls, if these are cool; on the other hand, the air may be so dry from overheating that cards or pictures hung on the walls may warp.

It follows from the theory of gases that warm air will deposit dust carried by it on any colder surfaces with which it comes in contact. The surface of old ceilings often appears whiter where backed by wooden laths than the parts where there is no such non-conductor of heat, and which are therefore on the average slightly colder; so, too, above steam pipes or radiators a sooty deposit is seen, or on ceilings above gas or electric globes, wherever a warm current of air impinges on a colder surface. For this reason, too, mechanically ventilated schools, with incomparably cleaner filtered air, appear dirtier, judged by the walls near inlets, than naturally ventilated schools without any provision for air cleansing; the appearance of dirt being wholly due to the relative temperature difference of the walls and the incoming air, and quite independent of the relative cleanliness or dustiness of the air.

CHAPTER V

MECHANICAL VENTILATION

Sufficent lighting and good ventilation are the most important requisites in a school. In actual practice, whilst many thousands of pounds may be spent in the erection and decoration of a school, a trifling and altogether inadequate sum is devoted to its ventilation, if special provision is not altogether ignored.

The cheapest efficient system is comparatively costly at first, and the best system will not give efficient results unless intelligent supervision is exercised.

The great difficulty of getting sufficient general movement of air in rooms, without excessive local movement in the form of draughts, makes mechanical ventilation almost a necessity for health in schoolrooms on the basis of space allowed by the Board of Education Regulations, with the smaller classes of about forty now being adopted.

Open Fireplaces.—A moderate sized room in a private house well exemplifies the difficulties in comfortable ventilation. A good fire drawing a considerable amount of air up the chimney only effects local movement of cold air along the floor; when the room becomes sufficiently warmed the air above the floor is heated, so that the room gets intolerably stuffy. The opening of a door or window is possibly followed by a cutting draught, but without such proceeding, the starting of a small electric fan in the room merely to stir up the air, at once removes the sense of discomfort. The open fireplace then provides a small head of air which by convection causes a rapid flow up the chimney; but for a classroom with forty or fifty children this would be wholly insufficient.

Various devices by which the air is heated by ventilating stoves or fireplaces are comparatively useless for general school purposes.

An open fireplace in a small classroom or teacher's room may, nevertheless, be made an adjunct to ventilation by the

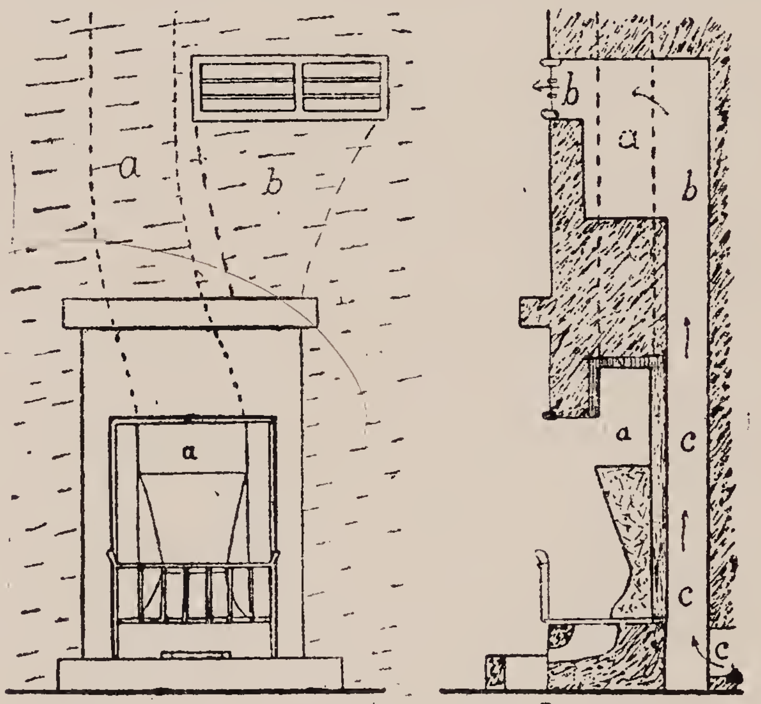


FIG. 40.—Galton's ventilating stove.

a, Smoke flue; *b*, air flue; *c*, air chamber.

use of certain devices. One of the best of these devices is that of Galton, and depends upon the utilization of the heat of the products of combustion going up the chimney. A chamber is placed behind the chimney, communicating at its lower end with the open air, and at its upper end with the room, by an opening over the mantelpiece. When the fire is alight, the air in this chamber is heated, and, therefore, rises into the room. Here it mingles with the fouled air; so long as the fire is alight, fresh air will continue to be delivered into the room, warm and above the breathing line. Moreover, as air is entering in this manner, less enters under the door and windows, and there are therefore fewer cold draughts. In such ventilating fireplaces, the lower the point of entry of the warmed air, the more complete is the admixture with the air of the room.

Used in this way, a ventilating stove acts as a means of setting up some circulation in the air of the room, and replaces the need for the small fan spoken of in a previous paragraph.

When schoolrooms are considered, all systems which depend on natural air movements for their head of air are liable to failure either when the external temperature is high or when there is little wind.

For a wholly dependable ventilation of schools, a head of air which does not fail must be always available.

The head depending on heating alone is very costly, but on a small scale can be utilized, particularly if a considerable height of chimney is available. This was the method adopted in the Houses of Parliament, a large fire being kept burning at the bottom of a chimney running up the Tower.

Nowadays, in practice a fan supplies the head. Under average conditions of English weather a low-pressure open-bladed fan is generally used, but for large buildings the enclosed blower is probably the most economical. It is used in the enormous American schools, driven by a motor in "sound-proof" housing.

Where a fan is used at the outlet, as in an air chamber in the roof, it is called an *exhaust* system. In this the choice of air supply cannot be regulated, nor can the air be controlled and treated to clear it from dust and dirt, so that the usual system is a *plenum* system, where a fan worked by a steam, petrol, gas, or electric motor drives air into the school. With the plenum system the air can be taken from a selected source under thorough control. A wide opening in the basement is generally used, with a few coils of heating pipes to temper the incoming air in winter and keep the screen through which it is next drawn from freezing. This screen, of large area to diminish resistance, may be made of jute cords, copper-wire gauze or a frame holding about 5 inches thickness of coke in pieces about the size of potatoes. Jets of water trickling over it wash and moisten the air. Occasionally a screen is used in the form of a large rotating cylinder, the lower part of which dips in a trough of water. The air must be well moistened, as Fig. 44 shows how it becomes relatively drier on heating. If heating of the air supply was not practised, it is probable that with the climatic conditions of England no humidifying arrangements would be necessary. The air is driven by the fan into the ventilating ducts. In nearly all existing schools it then passes over heating radiators before being delivered to the rooms, and as a rule there is no accessory heating of the rooms. It is through this attempt to combine air supply with warming that these mechanically ventilated rooms fail from the physiological point of view, the air being deteriorated in its ventilating qualities by the heating. As a means of heating, this system is probably the most wasteful that exists, as the specific heat of air is so low that it has to be overheated to supply enough to warm the rooms, the greater part of the heat, however, being carried unused to the outer air. The use of air for carriage of heat is therefore always to be condemned. The plenum system further requires that no other apertures, doors, or windows, except the outlet ducts should be maintained open, or parts of the building will become short-circuited. Doors and windows must be kept shut for efficient working of the air circulation. If the doors of one department, say the infant, are opened for a few minutes' recess, their area is generally so great that the ducts of the other departments, boys' and girls', are short-circuited, and do not get sufficient supply of air. This can be demonstrated by the sudden increase in carbonic acid or temperature in the atmosphere of these departments.

The best method of ventilation is to combine the two systems as shown in Fig. 41, so that the pressure in the rooms is nearly that of the outer air; doors and windows

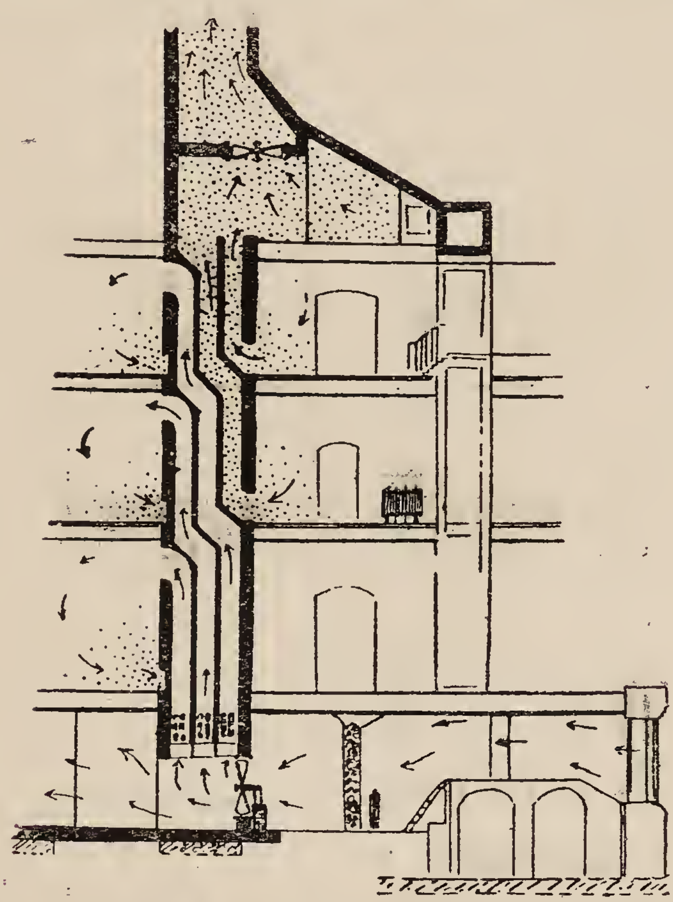


FIG. 41.—Diagrammatic section of part of a school.

Showing air entering in basement and being drawn through a coke screen, in front of which is a small radiator for tempering in severe weather. The air is then propelled by the fan into the main duct. Three room ducts, with small heating coils for severe weather, are shown going up the rooms. The extract shafts are shown dotted, and the extract fan in the roof chamber drawing air to the outlet.

then may be freely opened. With this combined system, of fans to drive air in and fans also to extract air, there is control of the air supply, but such a system will lose all its advantages unless the warming of the rooms is effected by the use of direct radiators, only sufficient heat being imparted to the incoming air to prevent chilling by draughts.

Meanwhile, in schools ventilated on the plenum system, sliding shutters should be provided to cover inlets in any rooms or halls likely to be unoccupied during school-hours so that they may be shut off and more air driven through the occupied rooms at that time.

From the main inlet ducts in the basement, ducts pass up to each classroom. Inlets are placed on the walls about 8 or 9 feet up, and have a wire screen of

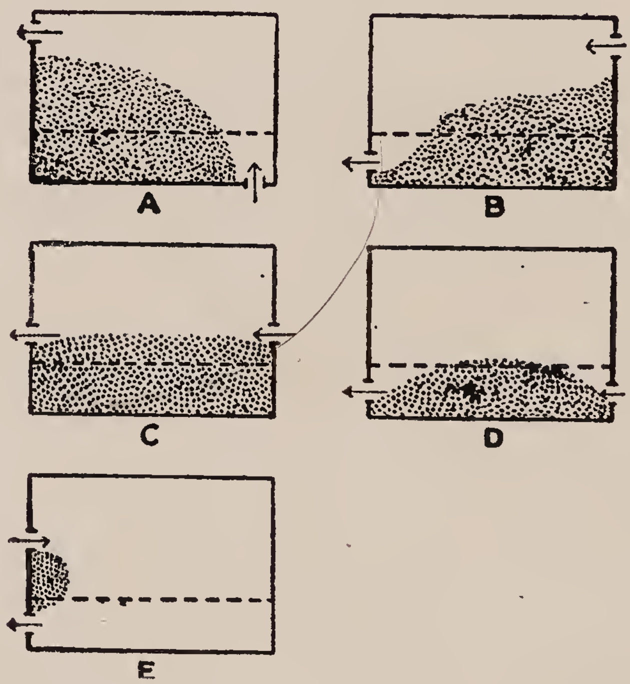


Fig. 42.—Showing in a combined "exhaust" and "plenum" system of ventilation the relative position of inlets and outlets of air giving purest air throughout a schoolroom.

about 2-inch mesh, to keep out foreign bodies. The outlets are placed nearly at the floor-level. In schools where gaslight is much used the heating effects may be greater than those of the children ; alternative outlets are therefore provided high up, which can be opened proportionately to the closing of the lower one to allow escape of the heated air from the gas burnt.

The best positions of inlets and outlets were determined by smoke tests in an experimental room, illustrated in

Fig. 42. The size of the ducts is of great importance; they are generally much too small if left to the architect, who always seems striving for economy here, and no subsequent increase of engine-power is likely to compensate for niggardliness in this respect in the original plans. A cross-section at the narrowest part requires a minimum area of 20 square inches per head; this is the least for

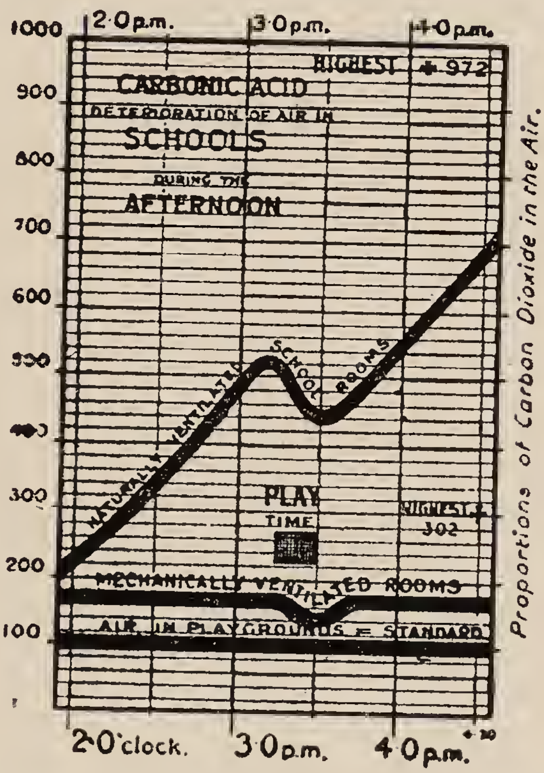


Fig. 43.—The steady increase of CO_2 except during play interval in naturally ventilated schools tested in quiet weather, September 1897. Highest reading 972 in naturally ventilated and 302 in mechanically ventilated rooms, the outer air being 100.

satisfactory working, and it is to be remembered that the wall opening must be much larger, as a considerable portion of this opening gives dead spaces when tested by the anemometer.

The advantage of mechanical ventilation over natural methods shows up astonishingly if measured by chemical means, or by the cleanliness from germs. Where, however, the incoming air is heated to 70° Fahr. or more, the dust deposited on the cooler wall surfaces at the inlets makes the school look dirty, and the rooms feel stuffy from failure of the warmed air to remove sufficient heat through the skin.

The purity of the air shows up in diminished absence from illness among both teachers and scholars; the mechanically ventilated schools in this respect being far the best if wide enough statistics are taken.

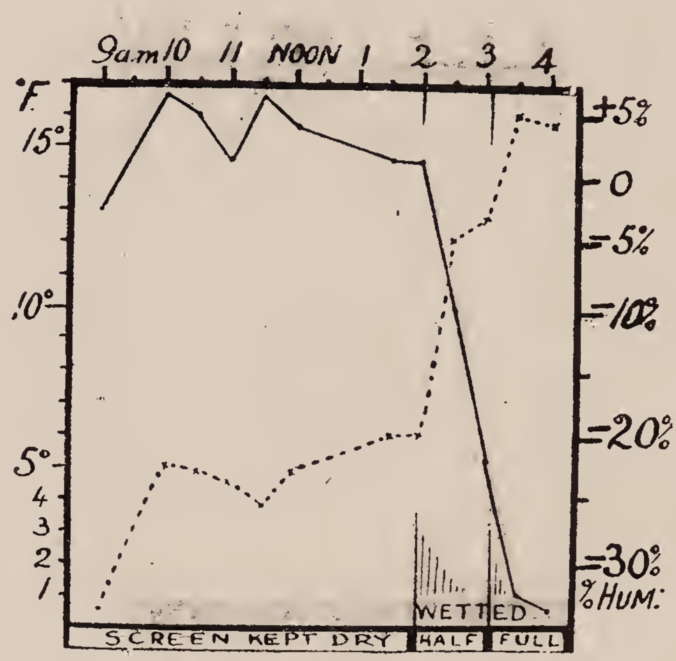


FIG. 44.—The drying effect of heating the air and later of also moistening it with first half, then the whole, of the screen wet, during school-hours.

Continuous line is temperature difference of air in ducts from outer air. The dotted line gives percentage of humidity below and above that of outer air. (Saturated air = 100.)

Fig. 44 shows the effect of the warming and moistening of the air, from actual measurements taken on an average day in a large school with plenum ventilation. For simplicity the excess temperature in Fahrenheit degrees over the outer air is given, and also the percentage relative humidity over the percentage relative humidity of the outer air, saturation in each case being 100. The screen being dry up till 2 o'clock, the only effect is to raise the temperature about 15 degrees and to dry the air, reducing the relative humidity about 30 per cent. When a half-supply of water is turned on the screen from 2 till 3 o'clock, the temperature falls owing to the large amount of heat which disappears in evaporation, and the humidity increases; when the full supply of water is used the temperature still falls and the humidity goes up till it is 5 per cent. in excess of the outer air.

CHAPTER VI

NATURAL LIGHTING

The lighting of schoolrooms is a matter second only to ventilation in importance. The present generation are beginning to feel the effects of increased, frequent, and long-continued use of the eyes. Overuse of the eyes is now almost habitual, and it is during the growing period that the effects of such overuse are especially serious. Lighting arrangements have largely followed architectural traditions till the last half-dozen years, when the introduction of easy methods of measuring light has made illumination a study in which almost any one who takes a little trouble may find interest.

School lighting divides into natural lighting, derived from daylight, and artificial lighting by various kinds of lamps.

In discussing the lighting of any object, the *illumination* or light falling on a surface must be clearly distinguished from the *surface brightness*, or light sent back from the surface, which is what the eye sees.

With the same illumination a piece of white blotting-paper will have a surface brightness of 80 per cent. of the light falling on it; a piece of dark brown paper will have 20 per cent., whilst a piece of black velvet will have about 0·5 per cent. To make the details of these different surfaces equally visible the illumination would have to be varied till their surface intensity was about equal in each case; which means that the velvet would require about 160 times and the brown paper about four times the illumination of the blotting-paper.

Standards of Illumination.—Candles were naturally the standard in which lighting was first measured when gas was introduced. A spermaceti candle, burning 120 grains of wax hourly, was agreed on as a standard. The illumination received from such a candle at a foot distance was termed a foot-candle, and the brightness of an illuminant was expressed in candle-power. The actual standards are derived from this, and are either a flame of a certain size, of a pentane or amyl acetate lamp, burning under defined atmospheric conditions, or else standardized electric glow-lamps.

The strength of a source of light is expressed in candle-power (I), and the illumination (E) received on a unit surface on which it falls perpendicularly, at the distance d is $E = \frac{I}{d^2}$. If, however, the surface is inclined to the direction of the light, or what is the same thing, the light is incident at an angle θ, this has to be corrected for, and then $E = \frac{I}{d^2} \cos \theta$. This is spoken of as the *cosine law*. If the surface only gives back a proportion (K) of the illumination, K being a constant amount depending on the surface, then the surface brightness (R) measured by a photometer, to be described below, is

$$R = K E = K \frac{I}{d^2} \cos \theta.$$

Photometers.—The measurement of illumination is done by apparatus whereby the light on a surface to be tested is judged by having another surface lighted by a measured illumination adjusted to equality with it. These photometers are of two kinds: (1) one giving quantitative measurements expressed in foot-candles, and needed for scientific investigations, or for measurements of artificial lighting; (2) relative photometers, giving measurements in relation to skylight, and chiefly used for rapid work with daylight.

Any recent book on modern illuminants will give details of the many varieties of these instruments.

A useful instrument for measuring illumination in schoolrooms is the "lumeter," Fig. 45, which occupies little space and can be carried in a leather case, slung on the back in the same manner as a hand camera. A piece of matt white celluloid is placed at the point where it

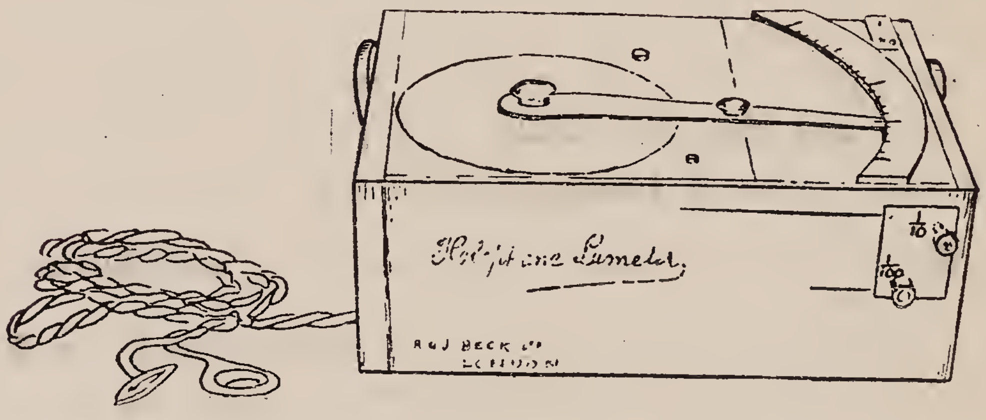


FIG. 45.—Lumeter—portable photometer for school use, giving surface brightness in foot-candles.

is desired to measure the illumination, and is observed from a distance. The instrument contains a small electric lamp fed by a portable accumulator, which illuminates a small white screen pierced by a central aperture. The illumination of this screen is adjusted by means of a movable shutter, and the observer looks through the aperture at the celluloid test-card, and adjusts the shutter until the brightness of the two surfaces is equal. The illumination is then registered on a scale graduated up to two foot-candles. By means of small dark glasses inserted in the path of the rays from the surface observed, this reading can be magnified 10, 100, or 1,000 times, so that the instrument reads up to 2,000 foot-candles. The instrument is calibrated for use by comparison with a standard lamp in the laboratory.

For relative photometry Thorner's light tester (Fig. 46) consists of an adjustable mirror and lens which throw an image of the sky on a white card in a little camera on a stand. An opening at the top allows this card to be seen, and also a round hole in it through which another test card on the stand of the instrument is visible. By placing stops over the lens the brightness of the sky

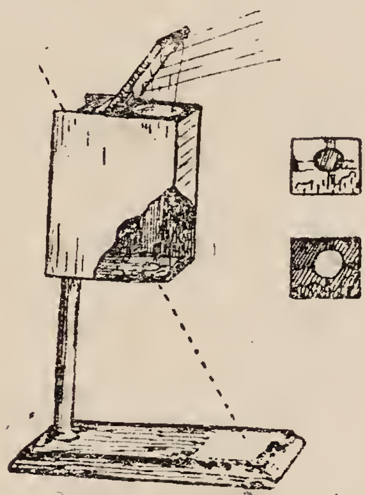


Fig. 46.—Thorner's light tester.

Showing appearance when the place is relatively too dark, and below when relatively light, compared with sky brightness as seen in the image.

image can be varied till the test card, as seen through the hole in the camera, looks as bright as the sky image. The lens stops $\frac{F}{5}$, $\frac{F}{6}$, and $\frac{F}{7}$, are supplied with the instrument. If $\frac{F}{6}$ has to be used to diminish the sky image below that of the test card, the place is too dark for schoolwork. A similar instrument with a graduated iris diaphragm can be used to compare any points in a room. Where sky brightness varies rapidly from minute to minute, some instrument like this, which compensates for the varying sky brightness, is necessary.

Other Methods.—The first investigators had no handy instruments for their work and had to trust to the eye, which, as has already been seen, from its extreme power of adaptation is very unreliable; still, the continued use of the eye is the real test of sufficient illumination. If diamond type at a test place can be easily read by a normal eye at half a metre distance the light is sufficient. Twenty years ago the writer used a card with square dots of 1·4 mm. edge, and the same distance apart, to be seen sharply as square dots from 20 feet distance, if the light was sufficient for testing visual acuity; otherwise they looked like a line. The dots should be larger, 1·75 mm. side and interval, as in Fig. 47, to test the minimum lighting permissible for a working place.

Fig. 47.—Square dots of 1·75 mm. side with the same intervals.

These dots should be clearly defined to a normal eye at 20 feet, if the light is good enough for schoolwork.

It was suggested by Cohn that a room would only be sufficiently lighted if the window area was not less than one-fifth the floor area, and he also pointed out that the effective window area was often seriously diminished by faulty construction or architectural embellishments. Javal, the French ophthalmologist, stipulated that from every desk some sky should be visible. Ultimately the value for average lighting of a certain area of sky was agreed upon. A square degree, that is, an area of one degree of angular opening vertically and horizontally, was used as the measure. But the light on a flat surface from a square degree vertically overhead would be greater than from a square degree near the horizon, so the *reduced square degree* was introduced. If any area is measured in square degrees ω, and it is at an average angular elevation above the horizon of a degrees, then it will give an amount of illumination equal to $\omega \sin a$ square degrees at the zenith; this quantity is its reduced square degrees. It was finally agreed that fifty reduced square degrees was the smallest amount of sky visible from any desk which could be allowed. This corresponds to about one foot-candle in the dullest weather.

Another way of estimating the amount of visible sky needed was to say that at least four degrees vertical must show at the top of the window, and that at any desk the angular height of the top of the window should be not less than twenty-seven degrees.

These geometrical methods, however, neglect the reflections, which may be considerable, in the room itself, from roof and walls, and which come into the reckoning with photometers. A factor has been sought to express this in the *sill ratio*, for any point, which is found by taking a simultaneous reading at the place to be tested and also on the window-sill outside. In a well planned school the ratio for the worst place should not be less than 1 : 100.

Rough Calculation.—Rough calculation can be based on the average sky brightness during school-hours being about 250 candles the square foot of window surface showing sky; the lower value may be taken as a hundred, and if 25 per cent. allowance is made for obstruction from glass and dirt of the windows, this is reduced to 75; then 75 multiplied by the number of square feet of window showing sky from the particular place gives the candle-power available through the window, and this divided by the square of the number of feet distance from the window gives the foot-candles available at the place. The minimum illumination of any school place should never fall below two foot-candles. With daylight it usually greatly exceeds this, and where sunshine falls may exceed 2,000, but actual sunshine has no business in a classroom.

The lighting, as already seen in discussing the reduced square degrees, is greater from the top of a window than from equal areas below. Windows should therefore reach as high as possible, and every inch is of value. Conversely, footboards or other means should not be used to raise desks higher from the floor than necessary, as it is equivalent to reducing the height of the room.

Window Area.—The rule as to window area being one-fifth of the floor area has been modified by Englebracht, who adds an average correction for the reflections from roof and walls. Where f is the window area in square feet, F the floor area, and x the width of the room, his correction will be $f = \frac{F}{5} \cdot \frac{x^2}{387}$.

Direction of the Light.—For the reasons already given high lighting is the most valuable. Owing to most children being right-handed it is necessary that light falls mostly from the left, to keep their handwork clear of shadows. Light in other directions causes shadows in awkward places.

Summary.—A School Lighting Committee of the Illuminating Engineering Society have summarized as follows:—

No place is fit for use in a schoolroom when diamond type cannot be read easily by a normal observer at a distance of half a metre (20 inches).

This is diamond type

The darkest desk in any schoolroom should receive an illumination equivalent to that derived directly from fifty reduced square degrees of visible sky. In these circumstances the place should receive not less than 0·5 per cent. of the unrestricted illumination from the complete sky hemisphere.

The windows should be located in the wall to the left of the pupils, and the glass carried to the ceiling, and not interrupted by cornices, pillars, or decorations.

No desk in a schoolroom should be further from the window wall than twice the height of the top of the glass above the desk surface.

The ceiling should be white; the wall opposite to the window and the wall behind the children lightly coloured from 30 inches above the desk level; the wall around or behind blackboards somewhat darker than the rest of the room.

All furniture, desks, and surfaces in the lower part of the room should be finished in an unobtrusive colour, dark shades and black being avoided.

Artificial Lighting.—Artificial lighting is necessary on some occasions, however short school-hours may be, and in winter becomes necessary nearly the whole afternoon in the North; indeed, there are European schools on which the sun does not rise for two months. Out of school, too, the student has to work at his tasks by this light, and increased use of schools for evening work makes artificial lighting both hygienically and economically important. The problems of illumination are simpler and more under control with artificial than with varying daylight. The illumination on the desks is generally much lower, although the minimum permissible is the same, two foot-candles.

Sources of Light.—Oil lamps may still be used in remote schools. The old Colza lamp of the past generation gave a steady, comfortable light, from a source of low intensity, and was preferable to bad gas-lighting, which was common. There is now practically only gas and electricity to consider. The naked batswing gas-jet is still seen flickering in some schools, condemning the inefficient administration which has not scrapped it long ago. Instead of this wasteful method, gas should be used to heat incandescent mantles. Where electricity is used it will be in the form of filament lamps; arc lamps may rarely be used, as in art rooms, but they need not have separate consideration. The distinguishing feature of modern sources of light is the high *intrinsic brightness*, that is, the high candle-power per square inch of illuminating surface.

The following are given as approximations to the intrinsic brightness of various sources of light in candle-power per square inch :—

Average sky brightness	2·5
Candle flame	2·5
Petroleum lamp	5·0
Flat gas flame	2·0–5·0
Diffusing opal shades	0·2–1·0
Incandescent gas, low pressure	10–30
Incandescent gas, high pressure	50–300
Electric lamp, carbon filament	400
Electric lamp, metal wire	800
Naked electric arc lamp, about	20,000

Evidently modern sources like incandescent mantles or electric filaments run into hundreds of times the intrinsic brightness of the sources of other days.

The average sky brightness of two and a half candles per square inch is about the highest which the eye can endure without feeling glare, and most writers agree that the image of any source of light greater than an intrinsic brightness of about 2·5 candles per square inch should not be allowed to fall directly on the eye. Shades or reflectors illuminated by primary sources of high intrinsic brilliancy are used as secondary sources. Thus, with an electric lamp lighting the inner side of an opal bowl, of many hundred times greater surface than the lamp filament, this bowl acting as a secondary source gives out light at not more than the 2·5 candles per square inch affording brilliant illumination, and yet it can be gazed at by the eye without discomfort. Reflectors are mainly used to direct and distribute light, but, like shades, they may also be used as transformers, so that the light from a primary small source of high intensity is changed to that from a secondary large source of low intensity, which the eye can tolerate.

From the health point of view there is little to choose between incandescent gas lighting and electricity. Whilst, even with the enormous improvements of recent years, gas heats the air more and therefore deteriorates it for ventilation, it is perhaps dustier, and requires greater attention to keep up to its full performance; it is possibly not so convenient, but probably cheaper for the light obtained than electricity.

Systems of Lighting.—The various modes of lighting are classified as *direct*, *indirect*, and *semi-indirect*.

The **direct** system is where the light passes straight from the source to the working plane, including any passage through refracting or dispersing shades. It is the most common house or school system, furnishing strong shadow contrasts, and is useful for local lighting where fine detail has to be made out. It is often trying for the eyes, in its uneven distribution and tendency to glaring contrasts and reflections, which, however, are relieved by the use of opalescent shades.

The **indirect** system has developed in recent years through the use of large electric arc lamps and high power incandescent "half-watt" lamps. Reflectors below the sources of light completely hide them from the eyes, throwing light upwards, which is reflected from the roof or from large specially designed reflecting surfaces. Similar methods are used in rooms with concealed cornice lighting, which can be suffused with a flood of soft light without the actual source being visible. With this method the light falling on the working plane is wholly reflected light, and from the large area of reflection is an evenly distributed light, soft from want of shadows and contrasts and abolishing glare. With the same illumination the uniform lighting causes the eye to be adapted for brighter conditions than with other systems, so that the room seems less bright, and the eye is not so sensitive. The very advantage of softness or absence of shadows makes details of texture more difficult to see, so that greater actual illumination is necessary on the working plane than with other systems, but for shadowless work like reading or writing, or in places like corridors, halls, or lecture theatres, it is a restful, agreeable mode of lighting.

The **half indirect** or **semi-indirect** systems combine many of the advantages of both systems. Opalescent shades below the lamps are adjusted to pass a considerable percentage of light, and the ceiling or reflectors above are also used to further distribution by wide reflection. Opalescent shades should give an intrinsic brightness comparable to, but not much above, that of the roof, thus obtaining freedom from tendency to after images but yet enough of shadows to make details easily seen. Glare is also diminished, so that this method is suitable for most schoolrooms.

Opal shades are best for school purposes. Glass bowls, cut or moulded in prismatic patterns, whilst diffusing light admirably, do not always prevent glare. If any images of the source of light are visible through them, although small, they are of a high intensity and may be decidedly glaring; cost, however, stands in the way for school use.

The arrangement of the points of lighting is important. They should be hung so that the lighting falls from the left, as with natural light. The points must be kept out of the field of vision of a child looking at the blackboard, and this last should have a special lighting from a considerable height and fairly close up to it, to avoid glaring reflexes. This source for the board should be completely screened from the class by an opaque reflector. Window blinds of a light colour to reflect light should be drawn at night, as all light passing out through the windows is lost.

CHAPTER VII

SCHOOL FURNITURE

One of the greatest difficulties with which the managers of a school have to contend is the provision of suitable furniture for the scholars. During a small portion of the school day the scholars may be standing or drilling, but usually are sitting at their desks. If all children of the same age were also of the same size, the selection of furniture would be easy; even if the size of the child and his standard of intelligence went together the difficulties would be slight; but under usual conditions, the difficulty can only be overcome by having a single desk for each scholar.

Before the necessity for suitable desks was realized, children of varying ages and sizes were often seen seated at a long desk holding perhaps six or eight, with the result that they were forced to assume attitudes which were both ridiculous and fraught with calamitous consequences.

This topic of seats and desks has accumulated an enormous literature, but the quest of the perfect seat or desk is as vain as the search for the philosopher's stone.

The growing child, and especially so the younger it is, whose muscles cry out for exercise and who yet has to sit at a desk for hours daily, is in an environment which aggravates tendencies in those who by weakness of constitution are disposed to myopia or spinal curvature. Muscular fatigue is the chief school element in both conditions, and the obvious remedy is to diminish or break up the continuous desk lessons into short periods, intermittent with more active work, standing at a table, or drawing at a blackboard.

For the prevention of the bad school habit of near eye-work-distance, and for the prevention of maintained unsymmetrical attitudes in which mere weight tends to deformity, the object aimed at is to have the child sitting evenly when reading or writing.

When upright, the sitter is balanced on the *tubera ischii* (seat bones), and the line of the centre of gravity falls between them. Balance is only retained by constant muscular action, chiefly of the back muscles, which soon leads to strain and muscular fatigue. If a third *point d'appui* is found, increased stability comes with the added support, and the muscle strain is relieved.

If the child sits a little back this relief can be given by a low back-rest; if forward, the front edge of the seat under the thighs may serve, or the edge of the desk pressing on the chest, or the legs or arms may be used for support.

The desk and seating problem therefore has to provide mainly for relieving fatigue in the writing position and in a listening position, when more relaxation is to be allowed for, and also to allow standing up in class.

For the working position the feet should be flat on the floor, the legs below the knees vertical, and the knees bent at a right angle. This gives the first measurement; the height of the top edge of the seat from the floor should be equal to the pupil's leg, in the position stated above and measured from the under surface of the thigh behind the knee to the sole. The next measurement is the width of the seat required, when sitting well back and upright, to leave the lower quarter or even third of the thigh free from pressure of the front edge. If the popliteal artery in this region is pressed upon, interference with the circulation of the leg may lead to numb, cold feet, "pins and needles," and possibly, in cold weather, chilblains.

The position of the desk edge (*distance*) in reference to the seat edge is shown in Fig. 48 as either (*a*) in the same vertical plane (*zero* or *null* distance), or (*b*) overhanging it by an inch or more (one inch *minus* distance), or (*c*) separated (*positive* distance). Minus distance is possibly best, but so long as it is not noticeably positive not much harm will be done; the child will be constrained

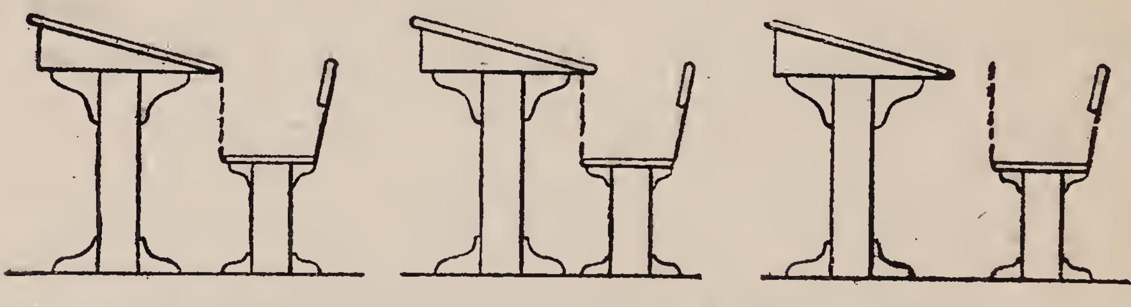


FIG. 48.—Three relative positions of seat and desk.

to sit up in writing, and to have its eyes 10 or 12 inches off the work.

The height of the desk edge must be found by trial. It is probably best just level with the lower tip of the sternal cartilage, so that the child sits comfortably with its arms on the desk without marked raising of the shoulders. Proportions between seat height and desk height are fallacious, as some children have long legs and others long bodies, although they may be the same height, so that *difference* between the height of the desk edge and the height of the seat is not a fixed ratio of the seat height.

The width from the desk edge to the plane of the lower back-rest should be about 2 to $2\frac{1}{2}$ inches greater than the child's antero-posterior diameter through the breast-bone.

A lower back-rest is required for the writing position; it should give support to the sacrum. A higher back-rest for the listener's position should give support a little below the shoulder-blades, and be inclined somewhat backwards. The back-rests should not be rigidly fixed, but work freely about an axis parallel to the desk edge, just behind the upper edge of the lower rest. With this arrangement there will be comfortable fitting; just as the nose clip of eye-glasses fits badly if the clip screw is tight, and comfortably if the screw is loose, so the back-rest will be satisfactory if afforded this play.

The dimensions for elementary school furniture in Bradford, which the writer determined many years ago after standardizing the children, were as follows:—

	Infants.		Standards.		
Sizes.	Babies.	Infants.	A. I and II.	B. III and IV.	C. V and VI.
	Ins.	Ins.	Ins.	Ins.	Ins.
Group height of children . .	38	42	45	50	55
Height of desk edge above seats	6	$7\frac{1}{2}$	8	$8\frac{1}{2}$	$9\frac{1}{2}$
Height of seat from floor .	9	11	$12\frac{1}{2}$	14	16
Size of seats	$11 \times 8 \times 1\frac{1}{2}$		$11 \times 9 \times 1\frac{1}{2}$		$11 \times 10 \times 1\frac{1}{2}$
Size of back rests	$8 \times 5 \times 1\frac{1}{4}$		$8 \times 5\frac{1}{2} \times 1\frac{1}{2}$		

The stock sizes of desks commonest in Central Europe have a minus distance of 2 centimetres, and the other dimensions in centimetres are as follows:—

Stock Numbers	I	II	III	IV	V	VI	VII	VIII
Group Heights of Children	up to 116	116 to 124	124 to 132	132 to 141	141 to 150	150 to 160	160 to 170	over 170
Height of seat above footboard	30·2	32·3	34·7	37·1	39·8	42·6	45·6	48·6
Footboard above floor	15·0	15·0	15·0	15·0	15·0	15·0	15·0	15·0
Height of back desk edge above seat	19·5	20·6	21·9	23·2	24 6	26 0	27·6	29·2
Depth of seat	22 5	24·0	25·5	27·1	28·7	30·3	32 0	33·7
Whole depth of seat and desk	62·3	63·8	66·3	68·9	72·3	74·9	77·6	80·3

This is perhaps the most widely used of all desks, and yet it is said to tire the children. Its form is shown in Fig. 49.

As children may grow about two or more inches in the year, the ideal provision would be an adjustable desk. Extensive American experience with adjustable desks shows that in elementary schools, where provided, they are scarcely utilized by the teachers, and an inquiry over a wide area found that 40 per cent. of the children were sitting at adjustable desks not suitable for their size. Further, it is on account of the tendency to crowd children together that the hygienist looks for a fool-proof seating, which will keep pupils separated instead of having three children crowded on the two seats of a dual desk, as so often happens.

The aim of separation of each child on its seat is of the highest importance, so that the single seat is a real necessity.

Isolation is needed to prevent dissemination of disease, not merely the acute infectious diseases, but grosser forms of sores, impetigo, scabies, or lice, and to dilute the offensiveness of odours from decaying teeth, discharging ears, dirty clothes, and other kinds of uncleanliness due to want of washing. Isolation is also required to effect sufficient ventilation. The condition of fatigue, so wasteful of educational effort, is largely due to the insufficient elimination of heat and aqueous vapour; this removal, as already explained, is a physiological necessity. There must be for health a definite free air space of some inches between

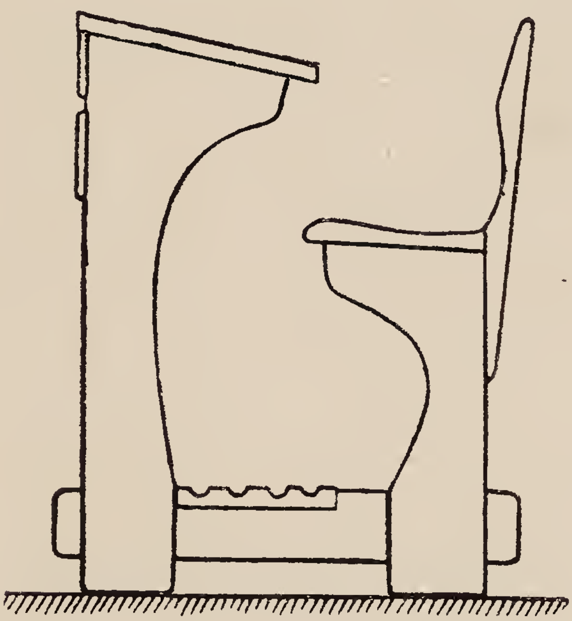


FIG. 49.—Profile of a dual seat and desk popular in Central Europe, of good dimensions above the footboard, which has the fault of being several inches above the floor.

each child and its neighbour. This excludes all forms of dual desk as hygienically unsatisfactory.

Width of Place.—Beyond saving space, insufficient attention has been paid to the width of place allowed to each child; it is also of importance in regard to isolation. Dual desks in London measure 40 inches long; with continuous desks and single seats (the Sheffield system) a place is 18 inches. Each child should be able to sit in its place with its hands clasped and arms extended along the desk without its elbows touching a neighbour. The Continental desks above give from 20 to 25 inches per place.

Single desks are the rule in secondary schools and in America. Till recently they have actually been refused recognition in elementary schools by the Board of Education, so that the majority have dual desks.

The dual desk crowds the children into contact, one child on the left, the other on the right, so that their positions are bound to be unsymmetrical. The children ought to be paired for each desk or the big boy crowds the small one. The likeliest chance of infection in a school is in the partners on a dual desk. It is, however, very convenient, as the children can stand out in their places, and they are also accessible for the teacher. Its great attractions to the builders and furnishers of schools are its compactness and the saving of room, which, however, are not always sanitary recommendations.

Chairs for Infants.—In the case of infant rooms small chairs are the handiest form of furniture. The writer experimented largely with these about twenty years ago, finding a plain back with side pieces preferable to the semicircular form. Little short tables at which four or six can sit are very adaptable for small children.

For evening work with adults, the small seats fixed in rooms for young children make the room useless for older pupils. Some forms of desks abroad have level footboards for the children about 5 or 6 inches from the floor; these can be turned back when wanted to suit adults, so that they can reach to the floor.

All seats and desks should have on them, when delivered at the school, a little enamelled plate or stencil stating the heights of the children who ought to use that particular stock number.

In recent years the objections to seats and desks of the ordinary models have been well recognized in America. There, where schooling is more generously provided than in this country, the space available—17 to 21 square feet per head—has led to employment of chairs with a swing table, adaptable to each child. An example of this furniture which seems to have much promise is the Moulthorp movable school chair. The pupil gets into the chair from the left side; it has a back, and on the right side an arm, on the outer end of which a table can swing horizontally at an adjustable height over the child's knees. A deep drawer beneath the seat opens on the left side.

CHAPTER VIII

THE CLASSROOM

The classroom is the school unit, so that a standard classroom may be discussed. Educational aspects have fixed the size of the secondary school class as not exceeding 30, whilst elementary schools are getting smaller classes and tend to about 40 children.

Vision.—Several of the factors which determine classroom dimensions have been separately examined, as lighting, ventilation, and warming; they will now have to be considered as interacting factors, but before that it must be recalled that about one-tenth of the children have visual acuity so low that they cannot make out test letters of a couple of inches in height beyond 26 feet distance; so that even with a good light this will be the limit for many for visible work on the blackboard; for the teacher this will also about limit his observation of the faces of the children.

Hearing.—Again, the teacher's voice must be considered. Although under good conditions normal children hear the forced whisper at 80 feet, for ordinary class purposes, and making allowance for many children with slight defects of hearing, 25 to 26 feet is about the available limit for the teacher's voice, and it is to save this that teachers are fond of gathering the children closely round.

For good visual and aural hygiene, then, the length of the room should not much exceed 26 feet. The width is determined by the lighting, for which windows must be carried as high as possible. The illumination will be sufficient across a room of width equal to twice the height of the top of the window above the desk surface. As with natural ventilation all space above about 10 or 11 feet is considered useless, and as in winter windows act as great coolers, they have to be as small as possible for the conservation of heat, so that the height of the room should be kept down to about 12 or 13 feet. With a window top of 12·5 feet, and desks of 27 inches height, there will be sufficient light in the room on desks up to 21 feet from the windows, so with a gangway the limit is reached about 22·5 feet in width. It is expensive to make wide rooms, as it also means high rooms only for lighting, the increase in height being of no service as air space, unless mechanical ventilation is used. Limiting sizes for a classroom are therefore about 13 feet height, 22 feet width, and 26 feet in length.

Desking.—The exact dimensions will probably depend on the seats and desks used. The class is commonly treated as 40, who can be placed in 4 ranks of dual desks with 5 desks in each. As already stated, dual desks ought to be rejected where they can be got rid of, separate desks being used. These could be arranged in 6 ranks of 7 desks for a class of 42. The width of a desk averages 2 feet and depth 2 feet 3 inches, and with an 18-inch gangway all round the walls, as there should be, and separate gangways between the ranks of 18 inches, with a 9-feet space in front of the class, there would be a classroom of 22·5 feet wide, 26 feet long, and 13 feet high. This is an area of 585 square feet, or just under 14 square feet per head, and a ventilating space of 140 cubic feet each. This is quite a modest demand. The Model Regulations of the National Education Association of the U.S.A. say not less than 15 square feet and 180 cubic feet per head.

Ventilation.—This is insufficient for natural ventilation. The cubic space must be potentially increased; this can be done by making one side of the room open to the outer air. Some recent schools have been arranged with the lower part to open, and the upper parts of the windows for illumination sloped like studio windows, thus getting increased lighting cheaply.

With these opening arrangements perflation is required, and this can be done where the classrooms are in detached wings by clerestory ventilating windows high up on the opposite side to the illuminating windows. As mentioned on p. 296, the heating where large masses of air are being moved in this way has to be on an extensive scale, but it is probably better in these open-air rooms to heat through the floors, so that the children's feet are kept warm. In some cases it is possible to get a ventilating window high up in the side wall behind the children. This window should be made to open upwards on the hopper principle, and its direct light should be shielded from the teacher by painting or obscuring the hopper so that no sky is visible through the window. As light is a desideratum, it might be reflected from the hopper on to the ceiling with advantage.

This standard room of 22·5 by 26·0 by 12·5 feet, even if the whole height be included as available for ventilation, would need 8·5 complete changes of air hourly to be ventilated. If, however, the height available for natural ventilation be taken as 10 feet, then the space of 140 cubic feet per head would require 10·5 changes hourly to give each child 1,500 cubic feet of air, which is only half the amount deemed necessary by the British Association Committee on the subject.

Such extensive air changes cannot be maintained without mechanical ventilation. Mechanical ventilation is a hygienic necessity for all classrooms with floor space under 20 square feet per head. Educational and economical considerations make this size of room unnecessary, although it is frequent in America, where, in addition, there is often further space as a cloakroom for each classroom behind the teacher's area.

Blackboard.—The blackboard should be facing the children and as nearly central as possible. The position of the blackboard to one side and partly turned towards the window, although it gets good light, still means twisting many of the children on their seats. Blackboards should not be fixed on the walls opposite the windows, unless they can be covered by light-diffusing blinds when not in use. To avoid glaring reflections the inclination of the blackboard should be up and forwards, and it should have a dead black coating half a dozen times a term if much used. Greenish tinted boards have been used, but have no special advantage. Ground-glass with a white background, or celluloid, which can be made non-inflammable, have been advocated, but black has advantages over white here. In America dark cement is commonly used to form a blackboard surface on the wall opposite the windows, but very materially darkens the room.

Lighting.—The whole lighting of the pupils' work should be from left-hand windows. A window on the right-hand side of the room is objectionable in practice, from the confusion produced by the shadows, for instance, about the pen-point in writing, and to obviate this Dinet has suggested ground-glass. The reflections, however, from a light-coloured wall are an obvious advantage, as they are in themselves of a low intrinsic brightness, so that they do not cause glare and produce scarcely noticeable shadow.

The lower parts of the room, on which most of the skylight is incident, should be lightly coloured—light neutral dove or grey or pale greenish tints, and not light-absorbing colours, as much of the light can again be reflected usefully from the roof or walls.

All shiny or varnished surfaces, polish of metal or paint, are to be avoided on account of glare.

It has been usual in classrooms built round a central hall to have the upper part of the partition glazed, on the idea that light was gained in this way. Measurements, however, show that it is lost to the classroom and that the loss is noteworthy. When the rooms are lighted artificially the loss is serious. These borrowed lights are scarcely ever required and should be avoided.

Floors.—The classroom floor is of interest as regards dust, cold feet, and wear by nailed boots. A jointless surface is desirable, although less necessary than in a hospital. Corticine has been found useful in cleanliness, noiselessness, warmth, and wear in some infant schools with stone floors. The floors of organic material and magnesium cement should not now crack as when first introduced, but they are cold, and wear slippery; so too *terazza*, except perhaps for corridors or cloakrooms. Oiled pine flooring, made more noiseless by embedding in sand, is recommended; although perhaps less durable, linoleum also conduces to silence. The ideal arrangement, however, seems to be a floor of cement composition through which heating can be done. The use of footboards has been condemned as tending to decrease the effective room height and window space. Stepped flooring has been used to raise the children, and although it has many advantages educationally, the disadvantage of the lighting is so great that it has been generally abandoned. Foot-rests are supposed to avoid cold feet, but with sufficient warming of the building, and not the air, this should not occur. The teacher sometimes has a platform of a few inches in height, whether also to preserve the feet from cold or as a remnant of the monkish days, which still determine so much routine of education, it is hard to say; but it is unnecessary, and the raising of the eyes of the children above a horizontal plane for long periods is to be avoided. This maintained raising of the eyes is, however, out of school, the most fruitful cause of cinema headaches.

For infant rooms the warming has to be carefully watched. Plenty of space beyond the 9 square feet, for games, and marching, running, and jumping, is a necessity for the classes of teachers who have emancipated themselves from the round of the Froebel mill. A most useful thing in the infant school is the provision of clothes-horses on wheels, which can easily be run out of the schoolroom and back to it when necessary.

Sleeping accommodation for a quarter of the children at a time is to be looked forward to. Sand trays, and plenty of room for free-arm drawing, not in desks but standing at wall boards, are not only educational advantages but requisites for physical development.

The Board of Education Regulations for classrooms have been materially improved in 1914, but in recognizing 10 square feet per head as sufficient space for the elementary school child, they do not yet approach the requirements of hygiene.

CHAPTER IX

SCHOOL CLEANSING

THE cleanliness of a school is important, not on account of the prevalence of tuberculosis, diphtheria, or other infections, as usually supposed, for the conveyance of any of these diseases in school dust is probably negligible, but for the maintenance of general health, and to reduce the frequency of common germs of low infectious power which are so common on the skin, in wounds and discharges of various kinds, sore eyelids, and corneal ulcers. It is to be remembered that any possible cleanliness will not save the child whose resistance is lowered from want of sufficient food and exercise.

Dust.—Dust may be irritating. Silica dust, for instance, is dangerous if exposure is frequent. The dust from chalk, from the soil, from hairs and shreds of clothing, and particles of epithelium may be a hundred times as great in school as in the outer air before the day is over. Dust on windows and lamps is out-of-pocket expense in increased lighting bills.

The prevalence of dust depends on the neighbourhood of streets and traffic, which, apart from noise, may even prevent open windows owing to dustiness; the playground surfaces, again, may require treating with dust-binding solutions, and the want of cleansing of the shoes on coming into school may be a large cause of dust.

The usual method of examining dust in the air is by drawing a measured quantity of air for about twenty minutes through a small funnel tube containing some 2·5 grammes of granulated sugar, so that, say, 5 cubic feet of air pass in the time. The sugar is then dissolved in 10 c.c. of distilled water, and a small portion of this placed in a counting cell; the particles of dust are counted with a two-thirds objective on the microscope. From a half to one million particles in a cubic foot of school air is comparatively unimportant.

Bacterioscopic methods are also used, either by testing the sugar solution or more readily by simply exposing culture plates for a definite time. The plates are then kept in an incubator and the number of colonies developing in a certain time are counted. The kind of result obtained is shown in the following note of observations in a room treated three months previously with dustless oil, and a control room treated by the ordinary soap and water washing and regular dustings.

	Numbers of Colonies of Micro-organisms.						Average.	Average some weeks later (Summer).
Plates . . .	1	2	3	4	5	6		
Dustless oiled room	6	18	9	12	5	6	9	78
Control room . .	580	800	600	650	900	850	700	4,000

The most common method is to sweep the floor daily with damp sawdust, moving and dusting the seats and desks each week, and every fortnight or so washing the floors with soap and water.

Oiled Floors.—The floor, having been washed with soap and soda and thoroughly dried, is oiled over during the holidays with a floor preparation thoroughly rubbed in with a rubber spreader. Different kinds of oils are used; the one selected should be odourless, clear, non-inflammable, and free from acid. The oiled surface is spoken of as dust-binding. The drawbacks are that women teachers are apt at first to get their dresses soiled, and that for a time the floor may be slippery. The floors darken considerably and look dirty, although the considerable reduction of dust in the air of the school remains unaltered for three months, when another coating of oil should be used, only about one-third the former quantity being now needed. The floor should be swept daily, no washing being required.

Vacuum Cleaning.—This method is being adopted in many recent schools, the schools being piped to a permanently installed apparatus in the basement. School-keepers object to this method, as it means picking up by hand the larger objects and pieces of paper. The cleansing, too, is rather time-consuming, but it removes instead of merely displacing dust. Several municipal inquiries have shown that school-cleansing methods in regard to cost and efficiency can be arranged as (1) vacuum, (2) oiling, (3) a long way behind—other methods.

The part of the dust in school due to use of chalk may be reduced by adopting dustless chalk. This is a misnomer, as it is not dustless, nor is it chalk, the body of the crayon being usually calcium sulphate. When weighted with various materials of non-friable nature a so-called dustless preparation is obtained. The greater part of the detritus from this falls and can be collected on a ledge or groove at the bottom of the board. Teachers should not use common chalk if they have any tendency to dryness or huskiness of the throat, or a disposition to cracked skin or dry eczematous conditions of the hands. Very small dusters are the best, but erasers are also used, which help to keep down chalkiness in the air.

Dust on windows may diminish illumination as much as 40 per cent. The writer once suggested in an infants, school report that "the frosted windows should be changed for clear glass," only to find that they were merely dusty. Shades and reflectors are also impaired in efficiency by dust, the cleansing, as in the case of windows, being generally too infrequent. It is important that these should be quite accessible, and that all parts of windows should open and be within reach. The footboards of desks, ledges, and panels are places which serve as retainers of dust in rooms; panels and beadings are generally unnecessary.

Disinfection.—Where dust is removed by a stationary vacuum apparatus installed in the school, disinfection need never be thought of. Except when a child has been sick it is a process rarely needed in a day-school. Apart from its moral sustaining effect, it is probably a waste of time and material. In the case of residential schools, or actual living rooms in which acute fevers like the zymotics have been treated, disinfection of clothing, curtains, and textile materials should be carried out by stoving at a central station. The walls and furniture should be sprayed over with formalin solution, and the floors scrubbed with soap and hot water; this will be sufficient disinfection for any school. Children are not required to live in aseptic surroundings, and the attempted sterilization of books or educational material can scarcely be other than waste of time. Washing is an adequate cleansing for pencils if there is reason to suspect that they have been infected. It is difficult to keep the ordinary pus organisms alive in modelling clay or to recover the diphtheria bacillus after a few hours. Any practical results of treatment of books or papers require so much care that destruction is probably the best treatment for such infected things.

Towels certainly serve to spread acute conjunctivitis; in addition, scabies may possibly be spread by sand or clay, but measles infection may be neglected so far as disinfection is concerned. The diffusion of scarlatina or diphtheria except by personal contact is very rare, and no case is on record where school material has been demonstrated as the cause of spread.

GLOSSARY OF A FEW MEDICAL TERMS

Most technical terms are explained in the text, but the meaning of a few medical words not there explained may be serviceable to those who meet them for the first time.

Adenitis, inflammation of a gland, e.g. cervical adenitis in the lymph glands of the neck.

Albuminuria, the symptom of disease associated with albumen in the urine.

Angular gyrus, one of the convolutions of the brain cortex. The word-vision centre is usually located about this gyrus on the left side of the brain.

Blepharitis is inflammation of the margins of the eyelids, frequently of a very chronic nature.

Cataract, opacities in the eye affecting the lens or its capsule.

C.G.S. Units, The system of units expressing scientific measurements in relation to the fundamental measures of centimetres, grammes and seconds.

Choroiditis is inflammation of the choroid coat (see Retinitis).

Diopters, see note on p. 147.

Emphysema, a disease characterized by tendency to shortness of breath, from distension and loss of elasticity of the alveoli of the lungs.

Exophthalmic goitre, a malady often presenting variable degrees of rapidity of pulse, protrusion of the eyeballs, fullness in front of the neck, tremors and highly emotional conditions.

Hæmophilia is characterized by liability to hæmorrhages from trivial causes, the so-called "bleeders'" disease.

Keratitis is inflammation in the cornea of the eye. Interstitial keratitis is deeply situated, and most often appears as a late manifestation of inherited disease.

Meningitis is inflammation of the membranes of the brain or spinal cord, very serious and frequently fatal.

Mydriatic means the power of producing a temporary paralytic dilatation of the pupillary opening.

Myopes are shortsighted persons, and in children, when the defect exceeds about six diopters, they are called high myopes.

Neurasthenia is a nervous disease showing excessive liability to irritation and rapid exhaustion.

Nystagmus, regular tremulous or oscillatory movements of the eyes, usually from nervous disturbance.

Ophthalmia neonatorum, inflammation of the surface of the eyes occurring in the first few days of life, resulting from septic infection at birth. It is now a notifiable disease.

Periosteum, the surrounding membrane of a bone, aiding its nutrition.

Phagocytes, the wandering scavenger cells of the body, resembling white blood corpuscles. They have the power of devouring or digesting dead or foreign bodies, germs and other materials.

Phlyctenulæ are small papules of chronic nature which may form on the conjunctiva or cornea, generally in ill-nourished children, and often leave permanent opacities resulting in defect of vision.

Retinitis is inflammation of the retina, resulting, when severe, in destruction of the nerve elements, with local loss of function. It generally also occurs under patches of choroiditis, which thus damage vision. *Retinitis pigmentosa* is a progressive nervous degeneration with some excess of pigment formation and slowly increasing defect of vision.

Stomatitis, inflammation of the mouth; often fatal among poorly nourished young children.

Sepsis, the foul conditions associated with growth of micro-organisms in or on the body.

Vitamines are certain complex chemical substances existing in minute quantities in fresh animal or vegetable foods and necessary for healthy growth.

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